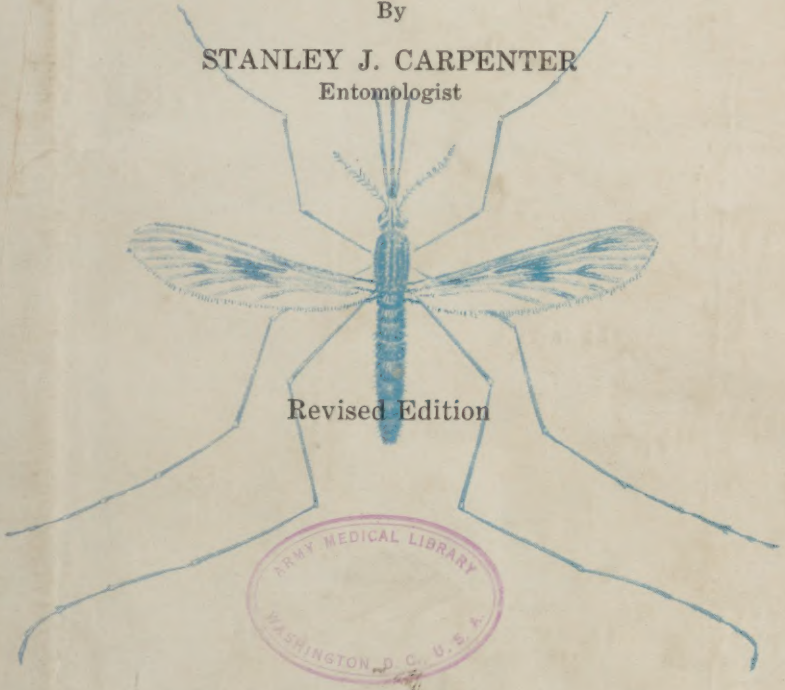
THE MOSQUITOES OF ARKANSAS

By

STANLEY J. CARPENTER
Entomologist



Revised Edition

ARKANSAS
STATE BOARD OF HEALTH
W. B. Grayson, M. D.
State Health Officer

Little Rock, Arkansas

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THE MOSQUITOES OF ARKANSAS

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FOREWORD

Successful mosquito control can seldom be obtained except as a result of a thorough study of the taxonomy, characteristics, and habits of the different species of an area. It is the object of this bulletin to present information about the mosquitoes of Arkansas which will be helpful to those interested in the investigation and control of this group of insects. These investigations began in 1937 in connection with the malaria control program being conducted by the Arkansas State Board of Health. Although the work has consisted principally of investigations dealing with the Anopheline species, some time has been given to the study of other members of the sub-family *Culicinae*.

Each of the forty-two species of mosquitoes recorded for Arkansas is briefly described in the following pages. The writer has drawn freely on the works of Thibault (55); Horsfall (31, 32); Matheson (46); Dyar (14); and King, Bradley and McNeel (40) for descriptions of *Anopheles walkeri* Theob., *Aedes bimaculatus* D. and K., *Aedes dupreii* Coq., *Aedes tormentor* D. and K., and *Theobaldia melanura* Coq., species previously recorded for Arkansas but which have not been taken by the writer in the State.

The collections on which this bulletin is based have been made in approximately sixty of the seventy-five counties of the State. The materials, including mounts of mosquito larvae, last larval skins, pinned adults, and permanent mounts of male hypopygia, are in my collections in the offices of the State Health Department.

ACKNOWLEDGMENTS

The writer is deeply indebted to Dr. W. B. Grayson, State Health Officer, for kindly interest shown and for making this work possible. My thanks are also due Dr. W. V. King of the United States Bureau of Entomology for rendering valuable assistance with methods of study and mosquito taxonomy. Field personnel of the State Health Department have been helpful on many occasions in obtaining material from different localities in the State.

INTRODUCTION

Ideal conditions are found in Arkansas for the development of some of the worst pest mosquitoes found in this country. In records dealing with the early history of the State, frequent references have been made to plagues of flood-water mosquitoes often making it practically impossible to plant, cultivate, and harvest crops in some areas after the recession of flood-waters. In some communities in Arkansas, mosquitoes are so numerous at times as to affect seriously the value of real estate. Industrial development in the eastern portion of the State is seriously hindered by the abundance of *Anopheles quadrimaculatus* Say, the common malaria mosquito; and pest mosquitoes.

Settlement of the lowland areas with the resulting improvement of the land for agricultural purposes, and the institution of flood control measures which have reduced the size of the overflow areas have certainly shrunk the breeding grounds of some of our pest mosquitoes in Arkansas. On the other hand, the agricultural development of the country seems to have brought about very little reduction in the production of *Anopheles quadrimaculatus*, the chief vector of malaria in the South, and in certain instances, such as the wet culture of rice, this species has certainly increased. Rice farming provides such ideal conditions for the development of *Psorophora columbiae* D. and K. that this species is commonly known as the "rice field mosquito" in Arkansas.

The development of the oil industry in Southern Arkansas, with the policy of dumping salt water into small streams, has created ideal breeding conditions for salt marsh mosquitoes, *Aedes sollicitans* Walker and *Aedes taeniorhynchus* Wied. These two species appear to be well established in Arkansas where favorable conditions exist for their development, and are now present in sufficient numbers at times to interfere with outdoor work.

The establishment of villages and towns with the accompanying pollution of water, increased numbers of artificial containers for water, and aggregates of human population have brought about more favorable conditions for the development of *Culex quinquefasciatus* Say, the common house mosquito; and *Aedes aegypti* Linn., the yellow fever mosquito. As sanitary conditions are improved, the importance of these species will no doubt diminish.

Effective control of mosquitoes cannot be obtained without a thorough knowledge of the taxonomy, habits, distribution, and flight range of the species involved. Studies

which have been made show very distinctly that different species often require different control measures. Successful mosquito control in New Jersey was obtained only after a study had been made of the habits of the troublesome species. Previous attempts to control mosquitoes in towns in New Jersey by local oiling programs were unsuccessful and a study of the mosquitoes present showed that the real culprits were breeding in salt marshes and had migratory habits, often being found nearly forty miles from their breeding places. Successful mosquito control in Arkansas can be brought about only by the proper application of control measures based upon a study of the habits of the species found within the borders of the State.

Intensive work on a mosquito investigation project in Arkansas for the purpose of determining the species present, their habits, distribution, and occurrence was undertaken by the State Board of Health in 1937. Since that time collecting has been carried on in every type of area within the State. Collections have been obtained from about four-fifths of the counties. Adult specimens were mounted, permanent mounts of fourth stage larvae and hypopygia were prepared, and the species were determined. The results showing the distribution of the different species and their ecology have been recorded and are available in the office of the Division of Malaria Investigation of the State Board of Health. The inclusion of separate specific records would be too bulky for a publication of this kind, and for this reason the distribution is stated in general terms except for some of the rarer species.

Previous to this present work, Horsfall (31) has made studies of the mosquitoes found in Southeastern Arkansas. Thibault in a publication entitled "Notes on Mosquitoes of Arkansas" gives some interesting and valuable information about species collected and studied in Lonoke and Pulaski Counties (55). A survey of the literature reveals other valuable works but restricted mostly to small areas and limited to a few species.

The following pages give the results of almost four years of work devoted to mosquito investigations in Arkansas under the direction of the Arkansas State Board of Health. Only the *Culicinae* or true biting mosquitoes are included. Very little space is given to taxonomy of mosquitoes in this bulletin, as this subject has been treated at length in the works of Matheson (46); Dyar (14); Howard, Dyar, and Knab (34), and others.

IMPORTANCE AND HABITS OF MOSQUITOES

Mosquitoes have limited man's habitation of many regions of the world and are claimed to be among the worst insect pests affecting man and his domesticated animals. At least four important diseases of man are transmitted by mosquitoes in North America. These diseases are malaria, yellow fever, dengue, and elephantiasis. Several animal diseases are known to be transmitted by mosquitoes. Certain members of the genus *Aedes* can be infected experimentally and can transmit the virus of equine encephalomyelitis to laboratory animals. It is thought that several species play an important role in the transmission of this disease in nature. Heartworm of dogs is transmitted by certain members of the genera *Anopheles*, *Culex*, and *Aedes*.

Very few people are acquainted with the habits of mosquitoes and it is surprising how many fallacies exist among those who are affected most by this group of insects. Mosquitoes are best known because of the blood sucking habits of the females; however, this habit is not universal and some species do not attack humans. Several species direct their attention to cattle and other mammals, while other species, such as *Culex apicalis* Adams, are said to feed on cold blooded vertebrates. The female of *Megarhinus septentrionalis* D. and K. depends on plant juices for food. The males of North American mosquitoes are not known to take blood and their mouth parts are not adapted for piercing. They feed principally on nectar and other plant juices.

A knowledge of the flight habits of mosquitoes is of much importance from the standpoint of control. The flight ranges of the different species of mosquitoes vary considerably, some species remaining in the vicinity of their breeding places while others migrate long distances. *Aedes aegypti*, the yellow fever mosquito, is a strong flier, but the usual flight range is probably not more than a few hundred feet. When planning control of *Anopheles quadrimaculatus*, the maximum effective flight distance is taken as about one mile or less under average conditions. The New Jersey salt marsh mosquito, *Aedes sollicitans*, has been known to migrate a distance of forty miles or more.

Some species of mosquitoes are strictly nocturnal, others diurnal, while several species fly both by day and night. Our Anopheline species are active principally at night. The dispersion flight begins at dusk and continues for a short period. Their activities are probably limited to short flights in search of a host during the remainder of

the night, except for a short period just before dawn, when the activity increases and they shift to daytime resting places.

It is difficult to obtain accurate information about the length of life of adult mosquitoes under field conditions. It is generally believed that male mosquitoes are short lived and live only a few days or weeks at the most. The span of life of the female mosquito is probably much longer than it is generally thought to be and may last several weeks for most species.

Practically all species of the genera *Aedes* and *Psorophora* in Arkansas pass through the winter in the egg stage. Larvae of *Theobaldia inornata* Will. have been taken in large numbers in the State from November to May but have never been taken during the summer. It is not known where the adults stay during the summer. However, adults have been taken in a trap during September and October in the State.

Mosquitoes pass through a complete metamorphosis consisting of four stages in their life cycle, which includes the egg, larva or wiggler, pupa or tumbler, and the winged adult or imago. The blood sucking species usually require a blood meal for the development of their eggs. During oviposition some species glue their eggs together, forming a floating mass or raft (pl. 1, C) ; others, including the *Anopheles,* deposit their eggs singly on the surface of the water (pl. 1, A, B) ; and certain other species deposit their eggs in moist depressions or on soil at the edge of the water where flooding is likely to occur. The eggs of several species are able to withstand long periods of drying and often require drying and exposure to cold before they will hatch. The incubation period is usually short during warm weather.

In their development, mosquito larvae pass through four larval instars. The length of the larval period will depend on the temperature of the water and the availability of a suitable food supply. The length of the larval period may vary from a few days to several weeks or months. Mosquito larvae feed on bits of organic debris, bacteria, small plants, and animals which they collect by action of their mouth brushes. Hinman (30) suggests that materials in solution and colloids in suspension may be used as a source of food by mosquito larvae. Mosquito larvae and pupae are adapted to a strict aquatic life and do not develop in damp vegetation.

COLLECTION AND PRESERVATION OF MATERIAL

A knowledge of the taxonomy and habits of the mosquito fauna of a particular area is an essential requirement for proper administration of control measures. The best means of obtaining this information is by collecting and studying the larvae and the adult specimens of the mosquitoes of an area. This should enable one to become intimately acquainted with the breeding requirements of the different species.

Collection of Larvae: Larvae of the genus *Anopheles* are usually found feeding and resting at the surface of the water among vegetation and debris, and can be collected by skimming through the surface layer of water containing such materials with a dipper or pan. Other mosquito larvae are more active and a quick stroke with the dipper is necessary to intercept them.

One of the most satisfactory devices for collecting mosquito larvae is a white enameled dipper with a hollow handle. The white background afforded by a dipper of this type enables the collector to find recently hatched larvae. It is an easy matter to make an extension for the dipper for collecting larvae from rather inaccessible places by inserting a stick or cane into the hollow handle. A shallow white enameled rectangular pan is useful for collecting most of the Anopheline species.

A suction tube consisting of a rubber bulb with three or four feet of attached rubber hose makes an excellent device for collecting larvae and pupae from tree holes and other places where a dipper can not be used.

Several different types of apparatus have been used for transferring mosquito larvae from one container to another, but a wide mouth dropper is about the most simple and convenient device available (pl. 2, A).

Half-pint sealing jars are convenient for carrying larvae and pupae to the laboratory for rearing. Several jars should be carried into the field by the collector in order that each collection can be kept separate. These jars can also be used in the laboratory for mass rearing of larvae.

Preserving of Larvae: An excellent medium for preserving mosquito larvae can be prepared as follows:

Formalin	10 cc
Borax	10 cc 5% sol.
Glycerine	0.25 cc
Water	Make up to 100 cc

Ten per cent commercial formalin or 70 to 80 per cent alcohol are excellent fluids for preserving the mosquito larvae for future identification. If the specimens are to be stored, one per cent glycerine should be added to prevent excessive hardening. Stored mosquito larvae often become dark and opaque, but can be cleared sufficiently for study by leaving them in a ten per cent solution of potassium hydoxide for a short time.

When mosquito larvae are to be preserved in the field it may be necessary to drop the live larvae directly into the preserving fluid, but whenever possible larvae should be killed by dropping them into hot water (not over 150° F.) before preservation. Larvae are quickly killed with hot water, thus eliminating the loss of hairs and other important structures by being allowed to struggle in a preserving fluid.

Rearing of Larvae: The rearing of larvae in the laboratory provides excellent specimens for building up a good mosquito collection. It is difficult to obtain perfect adult mosquito specimens without proper rearing equipment and technique in handling material.

A half-pint sealing jar equipped with a metal funnel and lamp chimney (pl. 2, B) is very satisfactory for the mass rearing of mosquito larvae. After practically all of the larvae have passed into the pupa stage, the jar should be wrapped with black paper to keep out the light. After emergence, the mosquitoes will fly toward the light, passing through the funnel and will be trapped in the lamp chimney.

Vials measuring 80 by 25 mm. are excellent for making larval isolations for individual rearing. A small cork float should be placed in each vial to serve as a resting place for the adult on emergence. The vials should be closed with cotton plugs. Larvae should be identified at the time isolations are being made and mounts should be made of the last larval skin and emerged adult to supply a complete mosquito record. Adults should never be killed until at least twenty-four hours after emergence, in order that proper development of coloration and sufficient hardening of the chitinous body wall will have taken place.

Proper feeding of larvae is a very important factor in rearing specimens but it would be difficult to make specific recommendations as to the kinds and amounts of food that should be used. The food should be obtained as far as possible from the pool from which the larvae are taken. Ox blood, yeast, pablum and other foods are often used to supplement the diet of mosquito larvae. Decomposition of

excessive amounts of food added often proves disastrous to larvae in the process of being reared.

Mounting of Larvae: Mosquito larvae of which permanent mounts are desired can be killed by dropping them into a dish of hot water (not over 150° F.). By means of a wide mouth dropper a single larva should be transferred to a clean glass slide and properly oriented by means of small dissecting needles. Excess water can be removed with filter paper and the specimen mounted directly in chloral-gum mounting medium. Larvae can be taken directly from preserving fluids, rinsed several times in clean tap water, and mounted directly in this medium. Chloral-gum mounting medium is also excellent for the preparation of permanent mounts of male genitalia.

Formula for Chloral-Gum Mounting Medium:

Gum Arabic	8 grams
Distilled Water	10 cc
Chloral Hydrate	74 grams
Glycerine	5 cc
Glacial Acetic Acid	3 cc

Warm the water and mix the first two, allow to stand over night and strain through three or four thicknesses of muslin, and add others in order. Several weeks are usually required for the mounts to harden. The cover glasses can be sealed by ringing them with cellulose cement.

A system of identification numbers should be adopted for keeping records on larvae, last larval skins, and adult specimens. Good specimens are often practically worthless because of the lack of complete accompanying records.

Obtaining Oviposition: Mosquitoes can be collected for making oviposition studies by the use of a live trap (pl. 3, A). When the mouth of the cone is placed over the resting mosquito, it immediately flies toward the light, thus passing into the jar. Strips of paper in the jar provide resting places for the mosquitoes, preventing them from beating themselves against the sides of the jar, which will rub off scales and destroy characters necessary for making accurate identification of the species. A suction tube (pl. 4, B) can be used to take live females for oviposition studies.

Plate 3, B shows an oviposition vial measuring 80 by 25 mm. This vial is very satisfactory for obtaining oviposition by single specimens of the different species of *Psorophora* and *Aedes*. Eggs can also be obtained from females of *Anopheles quadrimaculatus* with this type of oviposition vial. The damp cellucotton in the bottom of

the vial provides an excellent place for the mosquito to deposit her eggs and the white background makes it easy for one to see and count the number of eggs deposited. After the first oviposition the female can be fed again and introduced into another oviposition vial for further egg production. A match stem provides an excellent resting place for the adult mosquito.

A small percentage of female mosquitoes found resting usually have had recent blood meals and will produce eggs without further feeding. When recently fed mosquitoes are collected they can be isolated directly into oviposition vials.

One of the most satisfactory methods for obtaining accurate data on egg production is to collect female mosquitoes either resting or attempting to bite, feed them, and isolate them into oviposition vials. When the work is conducted in this manner, individual records can be kept on the length of time required to take a blood meal and the exact time between feeding and oviposition. When handled properly very few mosquitoes will refuse to take a meal while in captivity. The front portion of the forearm provides an excellent spot for feeding mosquitoes.

Collecting Adults: Methods used for taking adult mosquitoes will depend on the kinds of mosquitoes to be collected and the purpose for which the mosquitoes are to be used. A knowledge of the habits of the different mosquitoes is very important to the one collecting adult mosquitoes as well as mosquito larvae.

A chloroform killing tube (pl. 4, A) is very satisfactory for taking adult mosquitoes while feeding or resting. A glass vial one inch in diameter and six or eight inches long makes an ideal size for carrying in the field. A one and one-half inch layer of rubber for absorbing and holding the chloroform can be made up of one-fourth inch squares cut from an old automobile inner tube. The vial should be filled with chloroform to the top of the layer of rubber. A plug made from a piece of paper toweling is placed just above the layer of rubber. Several tight-fitting discs of blotting paper are placed above the paper plug. The vial should be equipped with a close fitting cork. A paper funnel guard is useful for preventing mosquitoes from escaping when several are being taken in rapid succession. Mosquitoes should be removed from the killing tube soon after killing has been completed, since absorption of moisture usually brings about discoloration of specimens.

A midge net may be used for collecting mosquitoes in the open. Mosquitoes should be carefully removed from the net with the aid of a chloroform killing tube. Care

must be exercised when collecting mosquitoes with a net to avoid rubbing the specimens beyond recognition.

A jar for keeping live mosquitoes (pl. 3, A) can be used for taking mosquitoes while feeding or resting. Mosquitoes collected in this manner can be kept alive for study and experimental purposes.

When large numbers of mosquitoes are to be collected for experimental purposes, a suction tube (pl. 4, B) can be used. A collecting tube of this type can be made by cutting the bottom out of an ordinary chemical test tube. A piece of open mesh cloth is used for a screen to prevent inhalation of scales, fragments, and debris. The rubber hose should be at least two and one-half feet in length in order that the collecting tube can be used in rather inaccessible places. Several mosquitoes can be taken in a tube of this type before it is necessary to transfer them to a cage.

A mosquito light trap of the type recommended by the New Jersey Agricultural Experiment Station (pl. 11, C) is excellent for sampling the mosquito population and for making studies of mosquito densities in a particular area. There are several species in Arkansas which are apparently not attracted to lights.

Mounting Adult Specimens: Adult mosquito specimens can be mounted on minuten nadeln pins on cork blocks, through which a larger pin is also passed. The mounts should be equipped with labels (pl. 5, A), and stored in Schmidt boxes. The tip of the small pin is inserted ventrodorsally through the thorax, usually from between the coxae, but should not be allowed to protrude through the mesonotum. When specimens are pinned in this manner the pleural sclerites of both sides can be used for checking certain important identification characters. The wings and legs can usually be pushed into correct positions shortly after the mosquito has been killed by using a dissecting needle, but care must be exercised to avoid removing body and wing scales which may be useful in the determination of the species. Mosquitoes should be mounted immediately after killing is completed when it is possible to do so; however, dry specimens can be relaxed in a moist chamber and successfully mounted if handled with care.

Each specimen should be labeled with the name of the species, collector's name, date, and collection number to correspond with the number on the card containing the collection data. Labels can be made by typing the exact form desired and photographing this form, reducing it to the actual size desired. A desirable sheet of labels can be

obtained by making a photographic reduction of one-fourth to one-sixth the size of the original typewritten sheet.

The ordinary Schmidt insect box is satisfactory for storing mosquito specimens. A holder containing a repellent such as flake napthalene or paradichlorobenzine should be placed in one corner of the box. A glass-topped exhibition case is satisfactory for displaying the different species of mosquitoes collected in a particular region.

Individual mosquito mounts placed in glass vials (pl. 5, B) are excellent for display purposes where specimens will likely be handled. Mounts of this type can be studied with the aid of a binocular microscope or hand lens without removing the specimens. Specimens which are to be mounted in this manner should be fumigated and sealed with paraffin.

MOSQUITO IDENTIFICATION

For the proper identification of larvae and adult mosquito specimens one should possess a basic knowledge of general insect taxonomy and the technique of preparing and handling specimens. Hand lenses, a compound microscope, and a dissecting microscope are essential for this work.

Identification of Adults: A good hand lens, giving a magnification of ten to twenty times, is indispensable for the identification of adult mosquitoes. A binocular microscope equipped to give magnifications ranging from twenty to eighty-five diameters should also be available and is necessary in order to carry on satisfactory work.

In collecting adult female mosquitoes, the specimens are often rubbed and broken to the extent that key characters necessary for accurate identification are missing. Accurate identification of some species is difficult even when adult female specimens are in perfect condition. In such cases it becomes necessary to make special preparations and studies of male hypopygia in order to make determinations of species with certainty. Matheson (46) gives a good description of the different parts of the hypopygium and their terminology, therefore a description of these structures is not included in this paper. Matheson's plates (46) show hypopygial structures in much detail and will be found very useful for the determination of many species of mosquitoes when closely studied with the aid of an ordinary reading glass.

The hypopygium can be prepared and mounted for study in the following manner:

(1) With fine pointed scissors clip off the last two or three segments of the abdomen of the male mosquito.

(2) Transfer to 10 per cent KOH or NaOH (solution should be in a small white porcelain dish with handle).

(3) Heat the KOH solution very gently until steam appears. If specimen was thoroughly dry and brittle, it should be kept in this solution from 3 to 5 minutes; soft specimens will need to be left in this solution 30 minutes or longer.

(4) Transfer to water and leave for ten minutes.

(5) Place a drop of chloral-gum mounting medium on the center of a glass slide and with the aid of a small dissecting needle transfer the specimen from the water to the mounting medium.

(6) Place the slide containing the specimen in the mounting medium under the high power of the dissecting microscope and with dissecting needles orient the specimen with claspers up. If the hypopygium is partly telescoped into the eighth abdominal segment, pull it out into full view. Using dissecting needles, straighten out the claspers.

(7) Place a small triangle of medium weight paper alongside the specimen to prevent too much flattening out when the cover glass is placed over the specimen.

(8) Before putting on the cover slip examine the structures carefully and locate all the parts.

(9) Seal with a cover glass.

(10) Label the slide, using the same identification number as that attached to the specimen from which the hypopygium was removed.

Identification of Larvae: A compound microscope equipped to give magnifications from 160 to 440 diameters is necessary for proper study and identification of mosquito larvae. The lower magnification is sufficient for studying most of the characters used for making identifications; however, for a detailed study of minute structures a higher magnification is necessary. An attempt should be made to build up a complete collection of mosquito larvae and last larval skins as well as adult specimens from a particular locality.

Workers, inexperienced in systematic work with this group of insects, should have on hand at least a small collection of correctly identified species of mosquitoes for comparative purposes. Correctly identified species can usually be obtained by sending specimens to a specialist with the request that named specimens be returned. Misidentifications are likely to result in serious difficulties and until one becomes thoroughly familiar with the different species, the material should be checked by an authority, especially when questions on control are involved.

CHARACTERISTICS AND EXTERNAL ANATOMY OF MOSQUITOES

The mosquitoes are small two-winged flies belonging to the family *Culicidae* of the order *Diptera*. Only the true mosquitoes comprising the sub-family *Culicinae* are included in this publication. The sub-family *Culicinae* is characterized by having the wings, legs, and other parts of the body more or less covered with scales, and the mouth parts produced into an elongated proboscis which is used by the female for piercing and sucking. The males can usually be distinguished from the females by their bushy, plumose antennae and the differences in length and shape of the palpi.

For the identification and study of mosquitoes it is necessary to know those structures used in the classification of this group of insects. No attempt is made in this bulletin to offer a detailed description of the external anatomy of either the adult or the larva of the mosquito. Only simple definitions and diagrams are given for explanations of the anatomical structures referred to in the condensed keys.

EXTERNAL ADULT STRUCTURES

The body of a mosquito, as in other insects, is divided into three major divisions: the head, the thorax, and the abdomen.

The Head

The head structures, commonly used in the identification of the different species of mosquitoes, are the proboscis, palpi, antennae, eyes, occiput and vertex.

Proboscis: This structure is commonly known as the beak and consists of the mouth parts which, in the female, are fitted for piercing and sucking. In the male mosquito, the mouth parts are generally modified and not adapted for

piercing. The visible portion is composed mostly of the labium which encases the other mouth parts. The two fleshy terminal lobes are the labella.

Palpi: The maxillary palpi consist of a pair of fleshy segmented structures found on either side of the proboscis. The palpi may be long in both sexes as found in the Anophelines, or long in the male sex and short in the female sex as found in most of the Culicines.

Antennae: These structures arise from the area in front of and are formed by the emarginations of the compound eyes. They are made up of fourteen segments each, the first of which is short and globose, the remaining thirteen are slender, each bearing a whorl of hairs.

Eyes: Ocelli are lacking in the mosquitoes and only compound eyes are present.

Occiput: The term occiput generally refers to that portion of the head capsule that lies just behind the eyes.

Vertex: The term vertex generally refers to the median portion of the top of the head.

The Thorax

The sclerites of the thorax bear stiff bristles arranged in rather definite groups. The arrangement and presence or absence of certain groups are valuable characters for separating certain genera and species. Important structures of the thorax used in the classification of mosquitoes are the mesonotum, spiracles, prothoracic bristles, prosternal bristles, pronotal bristles, spiracular bristles, post spiracular bristles, sterno-pleural bristles, prealar bristles, upper mesepimereal bristles, and lower mesepimereal bristles. The locations of these structures are shown in Plate 7, B.

Legs: The leg of a mosquito is composed of the coxa, trochanter, femur, tibia, a five-jointed tarsus, and a pair of terminal claws.

Wings: The wings of the mosquito are borne on the mesothorax. Plate 6, A shows the principal wing structures used in the identification of mosquitoes.

The Abdomen

The abdomen of the mosquito consists of ten segments; eight of these are visible in the female and segments nine and ten are modified for sexual functions. The male terminalium generally referred to as the hypopygium offers

excellent material for the identification of questionable species of mosquitoes.

EXTERNAL LARVAL STRUCTURES

A well prepared mount of the last larval skin, together with the mount of the emerged adult, makes a complete mosquito record. Some taxonomic structures used for the identification of mosquito larvae are the upper and lower head hairs, mouth brushes, antennae, antennal hair tuft, preantennal hair, lateral and subdorsal abdominal hairs, lateral comb of eighth segment, anal segment, dorsal plate of anal segment, lateral hair of anal segment, dorsal hair tuft, ventral brush, anal gills, air tube, pecten, ventral tuft of air tube and dorsal preapical spine. Most of these structures can be located by referring to Plate 6, B. Inner and outer clypeal hairs, inner and outer occiptal hairs of the head; and the palmate hairs, antepalmate hairs, and hair 0 of the fourth and fifth abdominal segments are particularly useful in the identification of *Anopheles* larvae (pl. 8).

SEASONAL OCCURRENCE OF MOSQUITOES

The collection of information on the seasonal occurrence of the different species of mosquitoes has been a major objective of the mosquito work which has been in progress in Arkansas since 1937.

A three year summary of the seasonal occurrence of mosquitoes, based on larval collections from September, 1937, through December, 1940, is presented in Table 1. Species of which only adult specimens or occasional larval collections are available are not included in the table, but information on occurrence of those species is included in the separate discussion of each species.

During the spring of 1940 an investigation of the early emergence of *A. quadrimaculatus* in Southern, Central and Northeastern Arkansas was undertaken. Male specimens were collected on May 21 in Southern Arkansas, on May 17 in Central Arkansas, and on May 28 in Northeastern Arkansas. The earliest date on which larvae of *A. quadrimaculatus* have been collected in Arkansas by the writer was on May 7, 1940, in Pulaski County, and the latest date for larval collections was on November 17, 1937.

The earliest collection of larvae of *Anopheles punctipennis* Say taken by the writer in Arkansas since 1937 was on March 8. Both *A. punctipennis* and *Anopheles crucians* Wied. begin their breeding earlier in the spring than *A.*

quadrimaculatus and continue later in the fall. Larvae of *Anopheles barberi* Coq. have been taken early in March by the writer in the State.

Theobaldia inornata is strictly a winter mosquito in Arkansas. *Aedes canadensis* Theob. and *Aedes thibaulti* D. and K. are usually found during the spring season. Horsfall (31) states that *Theobaldia melanura* is strictly a fall species abundant in Southeastern Arkansas during October and November.

Culex quinquefasciatus is a summer and fall species in Arkansas. Larvae of this species have been taken by the writer as early as May 26 and as late as December 15 during the period since 1937. A heavy production of *C. quinquefasciatus* is seldom found before late summer. The production of *Culex restuans* Theob. is frequently heavy in the spring in Arkansas, is light during the summer months and increases again during the fall season. *Culex apicalis* may begin breeding during March and may continue through most of November. *Culex erraticus* D. and K., *Culex salinarius* Coq. and *Uranotaenia sappharina* Osten-Sacken begin breeding about the same time as *A. quadrimaculatus* in Arkansas.

Larval collections of *Aedes aegypti* indicate that this species may breed intermittently throughout the year where conditions are favorable for their development. *Aedes vexans* Meigen, *Aedes sollicitans, Aedes taeniorhynchus,* and *Aedes atropalpus* Coq. develop intermittently during the spring, summer and fall months. Larvae of *Aedes triseriatus* Say, *Othropodomyia signifera* Coq. and *Megarhinus septentrionalis* may be found throughout the year except during extreme dry or cold periods.

Psorophora ciliata Fab., *Psorophora discolor* Coq. and *Psorophora ferox* Wied. are summer breeders. *Psorophora columbiae* usually begin breeding during the late spring in Arkansas and may continue until October.

TABLE 1. Seasonal Collections of Larvae of Common Species of Mosquitoes in Arkansas (September, 1937, through December, 1940).

Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
M. septentrionalis			—	—	—			—		—		
A. barberi			—	—	—	—		—				
A. punctipennis			—	—	—	—	—	—	—	—	—	
A. crucians				—	—	—		—		—	—	
A. quadrimaculatus					—	—	—	—	—	—	—	
C. apicalis			—	—	—	—		—	—	—	—	
C. erraticus					—	—	—	—	—	—	—	
C. quinquefasciatus					—	—	—	—	—	—	—	—
C. restuans			—	—	—	—	—	—		—	—	
C. salinarius					—	—	—	—	—	—	—	
A. aegypti		—	—	—	—	—		—	—	—	—	
A. canadensis			—	—	—							
A. sollicitans			—	—		—			—			
A. taeniorhynchus				—		—			—	—		
A. thibaulti			—	—	—							—
A. atropalpus		—	—						—	—	—	—
A. triseriatus			—	—	—	—	—			—		
A. vexans				—	—		—	—	—	—	—	
P. ciliata						—	—		—			
P. columbiae					—	—	—	—	—	—		
P. discolor						—		—	—	—		
P. ferox						—		—				
T. inornata	—	—	—	—	—						—	—
O. signifera		—	—	—	—						—	
U. sappharina					—	—	—	—	—	—	—	

KEY TO ADULT FEMALE MOSQUITOES OF ARKANSAS

Key to the Genera

1. Scutellum rounded; female palpi about as long as the proboscis ..... *Anopheles*
   Scutellum trilobed; female palpi usually much shorter than the proboscis 2
2. Second submarginal cell of wing short, less than half as long as its petiole 3
   Second submarginal cell of wing long, as long or longer than its petiole 4
3. Large, brilliantly colored mosquito with outer half of the proboscis strongly curved downward ..... *Megarhinus*
   Small mosquito with metallic blue scales on mesonotum and wings; proboscis normal ..... *Uranotaenia*
4. Thorax with spiracular bristles 5
   Thorax without spiracular bristles 6
5. Cross veins of wings tending to lie in a line (widely separated in *T. melanura*, a small mosquito which can be identified by black and brown wing scales and reddish-brown mesonotum) ..... *Theobaldia*
   Cross veins staggered ..... *Psorophora*
6. Tip of abdomen of female pointed, cerci usually visible ..... *Aedes*
   Tip of abdomen of female rounded, cerci usually not visible 7
7. Wing scales all large and broad ..... *Mansonia*
   Wing scales narrow or a mixture of narrow and moderately broad scales 8
8. Mesonotum with narrow, longitudinal lines of silvery scales ..... *Orthopodomyia*
   Mesonotum otherwise marked ..... *Culex*

ANOPHELES

1. Spots of pale scales on wings 2
   Wings wholly dark scaled 3
2. Costa dark scaled except a pale spot at tip of wing ..... *A. crucians*
   Costa with pale spot near tip of subcostal vein ..... *A. punctipennis*
3. Wings without spots ..... *A. barberi*
   Wings with spots of darker scales 4
4. Palpi ringed with white scales ..... *A. walkeri*
   Palpi without rings of white scales ..... *A. quadrimaculatus*

MEGARHINUS

The only representative of this genus recorded for Arkansas can be recognized by its large size, brilliant metallic colorations, and strongly curved proboscis ..... *M. septentrionalis*

URANOTAENIA

The only representative of this genus recorded for Arkansas can be recognized by its small size and the presence of metallic blue scales on mesonotum and wings ..... *U. sappharina*

THEOBALDIA

Wings very large and lightly scaled; wing costa, femora and tibiae sprinkled with white; cross veins tending to lie in a line ..... *T. inornata*
Wing scales all black and brown; mesonotum reddish brown; cross veins separated ..... *T. melanura*

PSOROPHORA

1. Uniformly colored mosquito ..... *P. cyanescens*
   Tarsi, proboscis, or mesonotum bicolored 2
2. Tarsi banded with white; legs very shaggy 3
   Both tarsi and proboscis banded with pale scales 4
   Tarsi banded with pale scales, proboscis not banded; legs not markedly shaggy 5
3. Large mosquito with a median stripe of golden scales on mesonotum ..... *P. ciliata*
   Large mosquito without median stripe of yellow scales on mesonotum ..... *P. howardii*
4. A medium to large sized mosquito peppered with black and white scales; wings with mixture of black and white scales ..... *P. columbiae*
   Brownish species; wing costa with pale spot at base and one at tip of subcostal vein; anal vein dark-scaled on apical third, basal portion pale scaled ..... *P. discolor*
   Brownish species; apical half of wing costa with two distinct black spots separated by a pale spot; anal vein with pale scales apically and basally ..... *P. signipennis*
5. Hind pair of legs with last two tarsal segments entirely white 6
   Next to last segment of hind tarsi white, distal segment dark ..... *P. varipes*
6. Mesonotum clothed with a mixture of brown and white scales ..... *P. ferox*
   White scales of mesonotum limited to the sides ..... *P. horrida*

AEDES

1. Thoracic integument yellow; a black spot in front of each wing ..... *A. bimaculatus*
   Otherwise marked 2
2. Tarsal segments banded with white 3
   Both the tarsal segments and proboscis banded with white 6
   Neither tarsi or proboscis banded with white 7
3. Joints of tarsi banded with white at base and apex 4
   Joints of tarsi banded with white on bases only 5
4. Mesonotum entirely reddish-brown ..... *A. canadensis*
   Mesonotum pale with dark broad median stripe ..... *A. atropalpus*
5. Mesonotum dark with four narrow lines of silvery scales arranged to form a lyre-shaped marking ..... *A. aegypti*
   Mesonotum dark brown; abdominal bands with distinct notches in the middle ..... *A. vexans*
6. Abdomen dark with a dorsal longitudinal pale stripe ..... *A. sollicitans*
   Abdomen dark but without a longitudinal pale dorsal stripe ..... *A. taeniorhynchus*
7. Mesonotum with longitudinal stripe of silvery scales or patches of pale scales on sides 8
   Mesonotum reddish-brown ..... *A. cinereus*
8. Mesonotum with longitudinal median stripe of silvery scales 9
   Mesonotum with patches of pale scales on sides 11
9. Silvery stripe of mesonotum broad, not reaching scutellum ..... *A. infirmatus*
   Silvery stripe of mesonotum reaching scutellum 10
10. Silvery stripe broad; almost entire mesonotum of male silvery scaled ..... *A. dupreii*

Median silvery stripe of mesonotum narrow
A. atlanticus or *A. tormentor*
(Separation of *A. atlanticus* and *A. tormentor* depends on larval or male genitalic characters.)

11. Mesonotum dark brown centrally; patches of silvery scales on sides ..... *A. triseriatus*
Mesonotum with broad median stripe of golden brown scales, sides yellowish-white to white ..... *A. hirsuteron*
Mesonotum with narrow dark brown stripe; sides of mesonotum golden anteriorly but ending abruptly about halfway back ..... *A. thibaulti*

MANSONIA

The only representative of this genus in Arkansas can be recognized by its broad wing scales and other characters listed in the key to the genera ..... *M. perturbans*

ORTHOPODOMYIA

There is only one representative of this genus in Arkansas. This species can be recognized by the jet black mesonotum with narrow longitudinal lines of silvery scales ..... *O. signifera*

CULEX

1. Tarsi and proboscis banded with white ..... *C. tarsalis*
Tarsi and proboscis without bands of white scales 2
2. Abdomen with apical segmental bands of white scales
C. apicalis
Segmental bands of abdomen basal when present 3
3. Broad basal segmental bands of white scales on abdomen 4
Abdomen unbanded or with narrow basal segmental bands 5
4. Abdominal bands rounded on posterior border and not joining lateral segmental spots ..... *C. quinquefasciatus*
Abdominal segmental bands continuous with lateral segmental spots; two white dots on posterior half of mesonotum
C. restuans
5. Medium sized mosquito; scales of occiput narrow and curved
C. salinarius
Small sized mosquito; some of the scales on the occiput broad and closely appressed 6
6. Scales of mesonotum golden; broad appressed scales limited to margins of eyes ..... *C. erraticus*
Scales of mesonotum brown with numerous bristles; almost entire occiput clothed with broad appressed scales
C. peccator

KEY TO THE FOURTH STAGE LARVAE OF THE MOSQUITOES OF ARKANSAS

Key to the Genera

1. No distinct air tube; abdomen with palmate hairs
ANOPHELES
Air tube elongate; abdomen without palmate hairs 2
2. Outer half of air tube attenuated and with saw tooth projections for piercing plant tissues ..... MANSONIA
Air tube normal, not greatly modified in form 3
3. Air tube without a pecten 4
Air tube with a pecten 5
4. Lateral comb of eighth abdominal segment a double row of long bars; mouth brushes normal ..... ORTHOPODOMYIA

Lateral comb of eighth abdominal segment a large chitinized plate with two stout hairs on posterior border; mouth brushes rod-like ..... MEGARHINUS

5. Head hairs single stout spines ..... URANOTAENIA
Head hairs normal, hair-like 6

6. Air tube with several tufts or single hairs extending beyond the pecten. (Pair of tufts at base of air tube in *Theobaldia*) 7
Air tube with single pair tufts at base or on distal half 8

7. Air tube with a pair of multiple tufts at base and long setae following pecten, or a single ventral row of ten or twelve short tufts ..... THEOBALDIA
Air tube without ventral tufts at base but with several pairs multiple tufts or single hairs beyond pecten ..... CULEX

8. Anal segment ringed by dorsal plate; hair tufts piercing ring ..... PSOROPHORA
Anal segment not ringed by the dorsal plate, or if ringed, the hair tufts of the ventral brush arise posterior to the plate ..... AEDES

ANOPHELES

1. Abdomen with plumose lateral hairs on first six segments ..... *A. barberi*
Abdomen with plumose lateral hairs on first three segments only 2

2. Hairs 0 and 2 with four to nine branches and nearly equal in size on abdominal segments four and five; lateral hairs on abdominal segments four and five branched at about basal third ..... *A. crucians*
Hair 2 usually single or double and hair 0 undeveloped or very small on abdominal segments four and five 3

3. Tubercles of inner clypeal hairs not closely approximated, separated by the diameter of a single tubercle; hair 2 on abdominal segments four and five usually prominent and single ..... *A. quadrimaculatus*
Tubercle of inner clypeal hairs closely approximated, separated by less than the diameter of a single tubercle 4

4. Inner clypeal hairs usually single and not forked; hair 2 of abdominal segments four and five usually double ..... *A. punctipennis*
Inner clypeal hairs feathered toward the tip; hair 2 of abdominal segments four and five usually single ..... *A. walkeri*

MANSONIA

The only representative of this genus in Arkansas can be recognized by the attenuation of the distal half of the air tube as described in the key to the genera ..... *M. perturbans*

MEGARHINUS

The only representative of this genus found in Arkansas is a large larva which develops in tree holes, or other wooden receptacles. It can be recognized by characters described in the key to the genera ..... *M. septentrionalis*

URANOTAENIA

The only representative of this genus in Arkansas has a very long head and single spine-like head hairs ..... *U. sappharina*

THEOBALDIA

Basal tufts of air tube small; a ventral row of small tufts beginning between the pecten and extending to near the apex ..... *T. melanura*
Basal tufts of air tube large; pecten followed by a row of long hairs reaching near distal end of tube ..... *T. inornata*

CULEX

1. Both upper and lower head hairs long and single, both hairs occasionally double ..... *C. apicalis*
   Both upper and lower head hairs multiple 2
   Upper head hairs multiple, lower long and single 5
2. Air tube with scattered single hairs beyond the pecten, a pair of small subapical tufts ..... *C. restuans*
   Air tube with several tufts beyond the pecten 3
3. Air tube with five pairs of tufts in a straight line beyond the pecten ..... *C. tarsalis*
   Air tube with penultimate tuft out of line 4
4. Air tube 7 to 8 x 1, and sides nearly parallel ..... *C. salinarius*
   Air tube 4 to 5 x 1, stout, tapering toward apex ..... *C. quinquefasciatus*
5. Lower head hairs single, upper short and usually double ..... *C. peccator*
   Lower head hairs single, upper short with four or more branches ..... *C. erraticus*

PSOROPHORA

1. Mouth brushes well separated, prehensile, hooked at tip and with teeth along sides 2
   Mouth brushes normal 3
2. Hairs of pecten teeth six times as long as body of tooth; lateral hair of anal segment with three or four branches near base ..... *P. ciliata*
   Hairs of pecten teeth three times as long as body of tooth; lateral hair of anal segment single or forked some distance from base ..... *P. howardii*
3. Antennae prominent, much longer than head 4
   Antennae moderate, usually shorter than head 6
4. Antennae strongly inflated ..... *P. discolor*
   Antennae cylindrical, normal shaped 5
5. Comb of eighth segment of six or seven subequal spines ..... *P. ferox*
   Comb of eighth segment of five spines, upper and lower small ..... *P. varipes*
6. Upper and lower head hairs multiple ..... *P. columbiae*
   Upper and lower head hairs single 7
7. Air tube with two long hairs at tip ..... *P. cyanescens*
   Hairs at apex of air tube short and inconspicuous ..... *P. signipennis*

AEDES

1. Tuft of air tube within the pecten 2
   Tuft of air tube beyond the pecten 4
2. Pecten with evenly spaced teeth; comb a single row of scales ..... *A. tormentor*
   Pecten with detached teeth distally; comb a patch of many scales 3
3. Lateral hair of anal segment single ..... *A. atropalpus*
   Lateral hair of anal segment double ..... *A. bimaculatus*

4. Pecten with detached teeth distally 5
Pecten with evenly spaced teeth 6

5. Pecten with one or two detached teeth distally ..... *A. vexans*
Pecten with three detached teeth distally ..... *A. cinereus*

6. Comb of eighth segment a few scales in a single or irregularly single row 7
Comb of eighth segment of numerous scales in a patch 10

7. Anal segment ringed by the dorsal plate 8
Anal segment not ringed by the dorsal plate 9

8. Anal gills very long and tracheae conspicuous; upper head hairs single, lower double ..... *A. dupreii*
Anal gills much shorter, tracheae absent; both pairs head hairs single ..... *A. atlanticus*

9. Comb scale with stout apical spine and shorter lateral spines; head hairs single ..... *A. aegypti*
Comb scale evenly fringed; upper head hairs single, lower double ..... *A. triseriatus*

10. Anal segment ringed by the dorsal plate 11
Anal segment not ringed by the plate 13

11. Scales of comb thorn-shaped or with distinct central spines 12
Scales of comb evenly fringed, without central spine *A. taeniorhynchus*

12. Lateral hairs on abdominal segments three to five double *A. sollicitans*
Lateral hairs on abdominal segments three to five single *A. infirmatus*

13. Both pairs of dorsal head hairs multiple 14
Lower head hairs single or double, upper multiple *A. hirsuteron*

14. Lateral hairs on abdominal segments one to five double, single on sixth ..... *A. canadensis*
Lateral hairs on abdominal segments one and two multiple, double on third to sixth ..... *A. thibaulti*

DESCRIPTIONS OF THE SPECIES

The brief descriptions which follow include female characters, description of the larva, distribution, breeding habits, and habits and importance of adult mosquitoes. The 42 species of mosquitoes recorded for Arkansas are divided into genera as follows: *Anopheles* Meigen 5, *Aedes* Meigen 15, *Culex* Linnaeus 7, *Psorophora* Robineau-Desvoidy 9, *Theobaldia* Neveu- Lemaire 2, *Mansonia* Blanchard 1, *Megarhinus* Robineau-Desvoidy 1, *Orthopodomyia* Theobald 1, and *Uranotaenia* Lynch-Arribalzaga 1.

Genus ANOPHELES Meigen

Five species of mosquitoes of this genus are recorded for Arkansas, all of which have proved susceptible to infection with malaria parasites and are able to transmit the disease to human beings. *Anopheles quadrimaculatus*, our chief vector of malaria, is more prevalent than other members of this genus in most areas of the State, excepting the more mountainous sections, where *Anopheles punctipennis* is more prevalent at certain times during the year. The

other species, including *Anopheles crucians, Anopheles walkeri,* and *Anopheles barberi,* are either too rare or their habits appear to be such that they are probably of little importance as carriers of malaria parasites in Arkansas.

The eggs of all our Anophelines are provided with floats and are laid singly but cluster in groups on the surface of the water (pl. 1, B). The larvae of *Anopheles* mosquitoes are easily recognized by the absence of a breathing tube and the fact that they rest and feed in a position parallel to the surface of the water (pl. 1, D). Adult Anophelines can be recognized by their typical resting position, the body being pointed at an angle toward the resting surface (pl. 1, H, I). An examination of Plate 1 will show important characteristics of the different stages in the life histories of both Anophelines and Culicines.

ANOPHELES BARBERI Coq.

Female Characters: A very small mosquito, the smallest of the Anophelines in Arkansas. Proboscis black. Palpi about the same length as the proboscis and brownish-black. Mesonotum brown medianly, gray on sides, clothed with long spine-like hairs. Wings of uniform color and clothed with black scales. Legs brownish-black.

Description of Larva: Head slightly longer than wide; frontal head hairs single; antennae short. Thorax about as wide as long. Abdomen with plumose lateral hairs on first six segments. Anal segment about as long as wide. Anal gills shorter than anal segment and pointed.

Anopheles barberi breeds in tree holes and stump holes where water collects and remains over a sufficient period to allow development through the immature stages and the emergence of the adults. They are frequently associated with larvae of *Aedes triseriatus, Megarhinus septentrionalis,* and *Orthopodomyia signifera* in their development. The larvae are very active and frequently dive when disturbed and will remain on the bottom longer than most species. A single tree hole seldom yields more than ten or twelve of these larvae during an inspection. Larvae have been collected from a tree hole near Little Rock as early as March 20. Production of these mosquitoes appears to be heavier during the spring and early summer than during the late summer and fall months.

Adults are scarce at all times. Thibault (55) states that the adults enter dwellings readily, are persistent biters, but are very nervous, and seldom finish a blood meal at one sitting. *Anopheles barberi* is susceptible to infection with malaria parasites but is probably of little or no importance in the transmission of this disease.

The distribution of *A. barberi* depends on the availability of suitable breeding places, since the breeding requirements are very specific. The species seems to be

widely distributed when breeding places are available in Arkansas.

ANOPHELES CRUCIANS Wied.

Female Characters: Proboscis clothed with dark scales. Palpi practically as long as the proboscis, base and apex of penultimate segment white, long segment with white ring near the middle, last segment white. Mesonotum gray, clothed with light colored hairs. Wings with patches of dark and light colored scales, dark costal margin, three dark patches on the anal vein, and a prominent patch of yellow scales at tip of wing. Legs dark; tips of femora and tibiae with patches of light colored scales.

Description of Larva: Head with plumose frontal hairs. Abdomen with plumose lateral hairs on first three segments only; hair 2 and 0 on abdominal segments 4 and 5 about equal in size and with four or more branches; lateral abdominal hairs on segments 4 and 5 branched at basal third.

Larvae of *Anopheles crucians* have been found by the writer in creeks, drainage ditches, roadside ditches, borrow pits, marshes, woodland pools, and cypress brakes in Arkansas. Larvae of this species are frequently associated with the larvae of *A. quadrimaculatus* and *A. punctipennis.*

Metz (48) claims that *A. crucians* prefer privies, outbuildings, and underneath dwellings for resting places and that they do not frequent the interior of dwellings in large numbers. *A. crucians* is primarily an out-of-door biter. The female is a known vector of malaria but due to its out-of-door habits it is not considered an important carrier of this disease. Adults have been taken by the writer from road culverts, underneath bridges, underneath dwellings, and inside outbuildings on several occasions in Arkansas.

There are two varieties of *A. crucians* recognized in the Southern United States, one that breeds in fresh water and the other in salt water. The fresh water variety can be picked up readily during the late summer and fall months in Arkansas. This species is scarcer than *A. quadrimaculatus* and *A. punctipennis* in Arkansas.

The female of *A. crucians* can be recognized by the presence of three dark spots on the anal vein of the wing, a dark scaled costal margin, and a prominent patch of yellow scales at the tip of the wing.

ANOPHELES PUNCTIPENNIS Say

Female Characters: Proboscis clothed with dark brown scales. Palpi black and nearly as long as the proboscis. Mesonotum with two broad median longitudinal stripes of gray scales, sides dark. Abdomen black and densely clothed with gray hairs. Wings clothed with patches of yellow and black scales. Legs dark; femora and tibiae tipped with yellowish-white scales.

Description of Larva: Inner clypeal hairs separated by less than the diameter of one of the tubercles; head with plumose frontal hairs; occipital hairs with few branches; usually no more than five. Abdo-

men with plumose hairs on first three segments only; hair 2 of fourth and fifth abdominal segments usually double, hair 0 small or undeveloped.

Anopheles punctipennis has a wider range in the character of its breeding habits than *A. quadrimaculatus*. Larvae have been taken by the writer from lakes, ponds, bayous, fish ponds, roadside ditches, rainwater barrels, tin cans, and temporary pools. They are apparently able to tolerate more filth than other Anopheline species found in Arkansas and are sometimes found in sewage-polluted water. The writer has on several occasions found the larvae of *A. punctipennis* associated with the larvae of *A. quadrimaculatus, Psorophora columbiae, Psorophora ciliata, Culex quinquefasciatus, Culex apicalis* and *Culex erraticus.*

Larvae have been collected on several occasions from small rock holes along Cedar Creek on Petit Jean Mountain with the larvae of *Aedes atropalpus*, a rock hole breeding mosquito. I have seen larvae of *A. punctipennis* blown by heavy winds into one end of a large pool, forming concentrations, when fifty or more larvae could be taken by a single dip. The larvae distributed themselves over most of the surface of the pool again within a short time after the wind ceased blowing.

The female hibernates in sheltered places during the winter. Adults are most active at twilight. *Anopheles punctipennis* is seldom found in human habitations. This species is not considered to be an important vector of malaria; however, the female can be infected experimentally with malaria and infections have been found in nature. Mitzmain (50) states that *A. punctipennis* rarely attacks persons inside dwellings, but often feeds on humans on porches, after which these mosquitoes seek resting places under the house in preference to the interior. Both males and females have been collected by the writer from daytime resting places, such as privies, road culverts, outbuildings, boathouses, hollow trees and underneath rock ledges. They are frequently associated with *A. quadrimaculatus* in their diurnal resting places.

Anopheles punctipennis is the dominant Anopheline mosquito of the hill regions of Arkansas. It is common throughout the lowland areas but is outnumbered by *A. quadrimaculatus* except during the spring and fall seasons. This species has a wide median gray stripe on the mesonotum and a light spot on the outer half of the costa of the wing.

ANOPHELES QUADRIMACULATUS Say

Female Characters: Proboscis light brown. Palpi about as long as proboscis and dark brown. Mesonotum brown and clothed with yellowish hairs. Abdomen black with numerous pale hairs. Wing scales light brown with four patches of dark scales. Legs dark; femora and tibiae tipped apically with yellowish-white scales.

Description of Larva: Head about as long as wide; basal tubercles of inner clypeal hairs separated by at least the diameter of one of the tubercles; outer clypeal hairs thickly branched; occipital hairs with more than six side branches (pl. 8, A); six plumose frontal hairs. Thorax about as long as wide; hair 1 of prothorax weakly branched toward tip. Abdomen with plumose lateral hairs on segments 1 to 3; hair 2 on segments 4 and 5 usually single (pl. 8, B). Anal segment about as long as wide; anal gills short and pointed.

Anopheles quadrimaculatus develops principally in permanent bodies of water, including lakes, ponds, borrow pits, swamps, and similar aquatic environments containing emergent aquatic vegetation or floating debris (pl. 9, A). They are apparently unable to tolerate much filth and industrial pollution in their breeding. Important Culicine pests are seldom associated with *A. quadrimaculatus* in their breeding in Arkansas. Larvae of *Uranotaenia sappharina*, *Culex erraticus*, and *Culex apicalis* are frequently collected with larvae of *A. quadrimaculatus*. Larvae of *A. punctipennis* and *A. crucians* are sometimes associated with larvae of *A. quadrimaculatus* in breeding areas.

The eggs are deposited singly upon the surface of the water and arrange themselves in definite patterns (pl. 1, B). Females have been observed, during oviposition, to dip the tip of the abdomen into the water and to move forward slowly, washing the eggs off as they were ejected. Eggs are yellowish-white when deposited but soon turn black after a few minutes of exposure to the air. Females will usually deposit eggs in small oviposition vials (pl. 3, B).

The larvae of *Anopheles* mosquitoes do not have a respiratory siphon and instead of hanging head downward, lie horizontally close to the water surface where they feed. They do not seem to make any selection of material in their feeding but injest any small particles which happen to come within their reach. Their food consists chiefly of small animals and plant organisms found on the water surface.

Larval development, at high summer temperatures and under favorable conditions, may be completed in about one week. With a minimum of three or four days for the egg and pupa stages and about four days for the preoviposition period, the minimum time for a complete generation would be fourteen to fifteen days.

This species is active principally at night and rests in dark buildings, underneath houses, in hollow trees and other shelters during the daytime. These mosquitoes leave their diurnal resting places just at dusk. They are very active for a short period after dusk but their activities are probably limited to flights in search of a blood meal during most of the remainder of the night, excepting another active period at dawn when they shift to their daytime resting places.

This mosquito feeds upon wild animals, man, and his domesticated animals. They are more domesticated than other Anopheline mosquitoes found in Arkansas and are frequently found in dwellings, where they rest in dark corners of rooms during the daytime. The flight range of *A. quadrimaculatus* from its breeding areas probably varies a great deal, depending upon nearness to blood meals and the numbers produced. In planning malaria control operations, a maximum effective flight range is usually taken as about one mile under average conditions.

The female of this species is considered the chief vector of malaria in the Southern United States and is susceptible to infection with all three types of malaria parasites. The male dies with approach of cold weather in the fall and the fertilized female passes the winter in dark well-protected places. These mosquitoes are widely distributed over the lowland areas in Arkansas, where conditions are favorable for their production. Their breeding is limited chiefly to impounded waters in the mountainous areas of the State.

Anopheline mosquitoes can usually be recognized by their typical resting position, the abdomen and beak being held at an angle toward the resting surface. Other kinds of mosquitoes hold the body more or less parallel with the resting surface. The palpi of Anopheline mosquitoes are nearly as long as the beak. *Anopheles quadrimaculatus* can usually be recognized by the presence of four dark patches of scales on each wing. The palpi are entirely dark.

Malaria control in Arkansas consists largely of measures directed toward a reduction of the production of *A. quadrimaculatus* or measures for protecting the human population against these mosquitoes through such measures as the use of bed nets, screens, contact sprays, repellents and fumigants.

The permanent elimination of important breeding areas of *A. quadrimaculatus* is the primary objective of malaria control. However, in planning extensive drainage work the problems of its effect on wildlife and other biological and physical factors must be considered. Other

measures frequently used against these mosquitoes are: filling; the removal of marginal or emergent vegetation from ditches, lakes and ponds; periodic fluctuation of water levels; and the application of chemical larvicides including petroleum oils, Paris green, and pyrethrum larvicide.

ANOPHELES WALKERI Theob.

Female Characters: Proboscis long and clothed with dark scales. Palpi nearly as long as proboscis, joints of palpi with white rings, apex of last segment white. Mesonotum brown, clothed with light hairs, patches of bristles near roots of wings. Wing scales brown with patches of dark scales arranged in similar manner to spots on wings of *A. quadrimaculatus*. Legs slender, dark; femora and tibiae tipped with yellowish-white scales.

Description of Larva: Larvae are similar to those of *A. quadrimaculatus* but differ in having the inner clypeal hairs closely approximated at their bases and with sparse feathering near tips.

Johnson (36) gives some interesting facts about the occurrence of *A. walkeri* in the region of Reelfoot Lake in Tennessee. This rare species breeds chiefly in fresh-water marshes containing aquatic vegetation. Bang, Quinby and Simpson (1), while working on this species in the Reelfoot Lake region, found that the adults remain hidden during the day deep in the swamps, sometimes on damp logs but more frequently in thick growths of Cut Grass, *Zizianopsis miliacea*. Fewer numbers were taken in damp barns, under bridges near the mud, and in springhouses.

Thibault (55) reports taking adults in fields and in woods near dwellings but never indoors. The females are said to be eager biters, attacking in the evening and long after dusk. The adults are very similar to *A. quadrimaculatus*, except that the palpi are ringed with white on the apices of the segments. Adults are taken more frequently in light trap collections than by any other means.

Thibault (55) reports taking this species in June, July, and December in Arkansas and states that the species is scarce at all times. *Anopheles walkeri* has not been taken by the writer in Arkansas.

Genus CULEX Linnaeus

The members of this genus in Arkansas are small to medium sized mosquitoes which breed principally in pools of water of a more or less permanent nature. At least two of the species are frequently found developing in artificial water containers. The eggs are deposited in raft-like masses on the surface of the water (pl. 1, C) and they hatch within two or three days during warm weather. There is a succession of broods during the summer months and the adult females pass the winter in hibernation.

Employing the classification used by King, Bradley, and McNeel (40), the seven Arkansas species of Culex may be placed in the following subgenera: *(Culex) quinquefasciatus, restuans, salinarius,* and *tarsalis; (Neoculex) apicalis;* and *(Melanoconion) erraticus* and *peccator.* Specimens of *Malanoconion* can be accurately classified through the use of certain larval characters or the preparation of mounts of the male terminalia, but adult female specimens are difficult to distinguish with certainty.

The larvae of the genus *Culex* are characterized by having long air tubes, usually with several multiple hair tufts. Adult females have blunt abdomens and a trilobed scutellum.

CULEX APICALIS Adams

Female Characters: A small mosquito. Proboscis dark brown. Mesonotum lightly clothed with pale golden scales, two narrow faintly impressed median lines. Abdomen dark with narrow apical segmental bands of white scales. Wing scales narrow and dark. Legs dark; femora yellowish below, apices of femora and tibiae white; tarsi dark scaled.

Description of Larva: Head large, wider than long. Antennae very large, spined all over, large tuft at outer third, constricted beyond tuft. Head hairs long and single, both upper and lower occasionally double. Comb of eighth segment of many scales in a triangular patch. Anal segment ringed by the dorsal plate and much longer than wide. Air tube at least 6 — 7 × 1, slightly expanded at tip; pecten on basal third of tube; four or five pairs of hair tufts beyond the pecten.

Larvae of *Culex apicalis* are frequently associated with *Anopheles quadrimaculatus* in water areas. Larvae have been taken by the writer as early as March 7 and as late as November 27.

Larvae have been collected from drainage ditches, borrow pits, creeks, marshes, lakes, woodland pools and ornamental fish ponds in Arkansas. On one occasion the writer found *C. apicalis* breeding in a large pot hole in a small intermittent creek near Little Rock in such numbers that a single dip yielded between 50 and 100 larvae.

Matheson (46) says that the adults of this species are not known to attack man but are recorded as feeding on cold blooded animals. The adults can be recognized by the presence of narrow white bands on the posterior margins of the abdominal segments.

CULEX ERRATICUS D. and K.

Female Characters: A small mosquito. Proboscis dark, slender, and enlarged at tip. Mesonotum brown and densely clothed with golden scales. Abdomen black, narrow segmental bands sometimes present. Wings clothed with narrow dark brown scales. Legs dark with bluish or bronzy reflections.

Description of Larva: Head wider than long; antennae large, longer than head, large multiple tuft beyond middle, constricted

beyond tuft. Lower head hairs single, upper short, with four or more branches. Comb of eighth segment with scales in a single or partially double row. Anal segments longer than wide, ringed by the plate. Air tube slender, 5 — 6 × 1; pecten on basal third; five pairs of multiple tufts beyond the pecten.

Culex erraticus breeds principally in permanent water areas. Larvae are frequently collected with the larvae of *Anopheles quadrimaculatus* in Arkansas. They are more closely associated with the larvae of *A. quadrimaculatus* than any other mosquito in the State, and the adults often occur in enormous numbers near extensive breeding places. The breeding season extends from late spring to December.

King, Bradley, and McNeel (40) claim that their observations at Mound, Louisiana, indicate that the species has a preference for the blood of fowls, attacking them on the roosts at night. According to Thibault (55), *Culex abominator* (probably *erraticus*) were very abundant and troublesome near Scott, Arkansas. The writer has never found the species troublesome even when adults were present in large numbers, and Horsfall (31, 32) did not find them of importance in Southeastern Arkansas.

CULEX PECCATOR D. and K.

Female Characters: A small species. Palpi much shorter than the proboscis. Occiput largely covered with broad appressed scales. Mesonotum uniformly colored, clothed with narrow scales. Outstanding wing scales, at least on branches of vein 2, short and somewhat broadened. Tarsi uniformly colored.

Description of Larva: Head broad; antennae longer than the head. Lower head hairs single, upper head hairs shorter and usually double. Comb of eighth abdominal segment of many scales in a patch, each scale rounded and fringed apically. Air tube 5 — 6 × 1, slightly expanded at the tip. Four to six long hair tufts beyond the pecten.

King, Bradley, and McNeel (40) state that the larvae of *Culex peccator* are usually associated with the larvae of *C. apicalis*. Matheson (46) states that this species breeds in small pools in marshy areas.

Male and female specimens of *C. peccator* have been collected by the writer on two occasions during August, 1940, in a springhouse in Boyle Park near Little Rock, where they were resting underneath a projecting rock over which water pours continuously. The feeding habits of the adults are apparently not known.

CULEX QUINQUEFASCIATUS Say

Female Characters: A medium sized mosquito. Proboscis brown toward tip. Mesonotum clothed with narrow light brown scales. Abdomen black with basal segmental bands rounded on posterior margin, interrupted at sides and not joining lateral spots. Wings clothed with narrow brown scales. Legs dark brown with metallic blue reflections.

Description of Larva: Head wider than long; antennae somewhat shorter than head, spined all over, multiple tuft at outer third, constricted beyond tuft. Upper and lower head hairs multiple. Comb of eighth segment of many scales in a triangular patch. Anal segment slightly longer than wide. Air tube about 4 × 1; pecten of many teeth on basal portion; four pairs of hair tufts beyond the pecten, subapical pair laterally out of line.

The female of *C. quinquefasciatus* deposits her eggs in rafts on the surface of the water. This species prefers sewage-polluted water in which to develop; however, they are frequently found in town ditches containing industrial waste or filth, in rainwater barrels, catch basins, and artificial containers. Cesspools, open septic tanks, and effluent drains from sewage disposal plants offer ideal conditions for the development of this species. A heavy production of *C. quinquefasciatus* is usually associated with insanitary conditions and in many of our towns this species has become of very little or no importance as the result of the adoption of better sanitary measures.

The females are fierce biters, attacking mostly at night. They have the singing habit well developed, and a single female may be responsible for a sleepless night for a person not accustomed to mosquitoes. Production of this species in towns with insanitary sewage disposal facilities sometimes reaches such proportions that they become a scourge to the community. Annual appropriations are made by many of our towns in Arkansas for the control of this species. Adults rest in outbuildings and other dark places during the day. Breeding is continuous from early summer to November or December throughout most of its range in Arkansas. The female passes the winter in hibernation.

Culex quinquefasciatus is the common house mosquito of Arkansas and is well distributed over the State where suitable breeding conditions are found. The production of this species is usually light in Northwestern Arkansas.

CULEX RESTUANS Theob.

Female Characters: A medium sized mosquito. Proboscis with dark brown scales. Mesonotum clothed with narrow rich brown scales, two median longitudinal bare lines, two inconspicuous white spots usually present on posterior half of mesonotum. Abdomen brownish-black with broad basal segmental bands rounded on posterior margins and continuous with lateral spots. Wings clothed with narrow brown scales. Legs brownish-black; femora pale scaled underneath.

Description of Larva: Head slightly wider than long; antennae somewhat shorter than head. Upper and lower head hairs multiple. Comb of eighth segment of many scales in a patch. Anal segment about as long as wide, ringed by the plate. Air tube approximately 4 × 1; pecten on basal third; two or three pairs of long single hairs and a pair of small subapical tufts beyond pecten.

Culex restuans develop in various breeding places, including ornamental pools, borrow pits, town ditches contain-

ing filth, rainwater barrels, tin cans, and woodland pools. They are frequently found developing in enormous numbers in water containing sewage. Breeding of this species is usually heavy during the spring season in Arkansas, is light throughout the summer months, and increases again during the fall season.

Culex restuans is a semi-domesticated species frequently entering houses but not equal to *C. quinquefasciatus* in this respect. Adults are more numerous during the spring and fall months than during the summer season.

King, Bradley, and McNeel (40) claim that they are troublesome biters. The observations of this writer have been that they are seldom troublesome in Arkansas except when adults are present in large numbers. The adults usually have a pair of indistinct white dots on the mesonotum.

CULEX SALINARIUS Coq.

Female Characters: A small to medium sized mosquito. Proboscis black. Mesonotum clothed with rich brown scales, two bare median longitudinal lines present. Abdomen bluish-black with narrow basal bands of creamy-white scales on anterior segments. Wing scales narrow and brown. Legs with dark brown scales; femora pale scaled underneath.

Description of Larva: Head slightly wider than long; antennae longer than head, curved outward, multiple tuft on outer third, constricted beyond the tuft. Upper and lower head hairs multiple.

Comb of eighth segment of many scales in a patch. Anal segment about as wide as long. Air tube about 6 — 7 × 1; pecten of many teeth on basal portion of tube; four pairs of hair tufts beyond the pecten, subapical pair laterally out of line.

Culex salinarius is commonly encountered in Central and Eastern Arkansas where marshy areas are numerous. Larvae of *C. salinarius* have been collected by the writer in roadside ditches, woodland pools, borrow pits, lakes, cypress pools, and other marshy areas in Arkansas since 1937. Larvae were most common from July through early November.

According to Matheson (46) the females of *C. salinarius* frequently enter houses during the evening and bite readily. The writer has collected adults in outbuildings but has never found them inside dwellings.

CULEX TARSALIS Coq.

Female Characters: A medium sized mosquito. Proboscis black with white band near the middle, terminal portion with a few gray scales. Mesonotum dark brown with golden scales along the sides and roots of the wings; a narrow white line on each side extending a short distance forward in front of the wings. Abdomen clothed with narrow dark brown scales. Legs brown; tarsi with white bands on each side of joints.

Description of Larva: (Dyar) "Head rounded, wider than long; antennae large, a tuft at outer third. Head hairs multiple. Comb of eighth segment of many scales in a patch. Air tube slender, uniform, about 4 × 1; pecten on basal third followed by five paired tufts, basal one within the pecten. Anal segment longer than wide, ringed by the plate."

Larvae of *C. tarsalis* were collected by the writer during November, 1937, from a semi-permanent marshy area in Greene County and from a roadside ditch in Craighead County and reared. Hearle (25) states that no water is too foul for *C. tarsalis*, larvae often being taken in filthy pools in cattle yards. Eggs are laid in rafts.

According to Hearle (25) *C. tarsalis* is a painful biter and the numb pain and swelling which follow probing lasts for hours. Dyar (14) states that the adults enter houses to some extent but are not as persistent either in entering houses or biting as *C. quinquefasciatus*. The female hibernates during the winter. This species is seldom present in large numbers in Arkansas; however, they were taken in larger numbers than any other species in light trap collections during September and October, 1940, on Camp Robinson military reservation near Little Rock.

Genus AEDES Meigen

Fifteen species of mosquitoes belonging to this genus have been recorded for Arkansas. Members of this genus display a wide variety of breeding conditions, including artificial water containers, tree holes, rock holes, salt marshes, temporary rain pools in meadows, temporary woodland pools, and floodwaters.

The eggs of *Aedes* are deposited singly on damp surfaces above the water level of pools or in damp depressions subject to flooding, and are able to withstand long periods of drying. When the areas in which the eggs have been deposited are flooded, some of the eggs hatch; others may not hatch until subsequent floodings. Some species of *Aedes* have several annual broods occurring during the rainy season whereas certain others have but one brood each year. The females have progressively tapering abdomens with prominent cerci.

AEDES AEGYPTI Linn.

Female Characters: A small sized mosquito. Proboscis slender and brownish-black. Mesonotum clothed with brown scales, silvery white lyre-shaped markings present on dorsal surface, antescutellar space margined with white. Abdomen black, each segment except last with a narrow basal band of white scales and a row of white lateral spots on each side. Wings entirely clothed with brown scales. Legs black, hind legs with tarsal segments basally ringed with white and last segment entirely white, first two segments of fore and mid tarsi basally ringed with white.

Description of Larva: Head rounded, about as long as wide; antennae short, smooth, a single hair at middle. Head hairs single. Comb of eighth segment of several scales in a single row. Anal segment not ringed by the plate. Air tube short, about 2 × 1; pecten teeth rather small and reaching middle of tube; multiple tuft beyond pecten.

Aedes aegypti prefers artificial containers such as eave troughs, flower vases, concrete troughs, cans, and similar receptacles for the development of its immature stages. Leaves and wood debris are usually present in containers where larvae are found; however, this is not always true. This species will breed during the winter months inside warm buildings where flower vases or other receptacles contain water.

Aedes aegypti is a diurnal species, the females attacking mostly during the day. The female of this species is rather wary, usually coming from behind and attacking around the ankles. *Aedes aegypti* is our most domesticated mosquito in Arkansas and seldom travels far from its breeding places. They are plentiful during the summer in cities and towns in the State.

AEDES ATLANTICUS D. and K.

Female Characters: A medium sized mosquito. Proboscis dark brown. Mesonotum with wide median longitudinal stripe of gray scales, sides golden. Abdomen bluish-black, lateral spots of yellowish-white scales. Wings clothed with narrow brown scales. Legs brown.

Description of Larva: Head much wider than long; antennae small, shorter than head, multiple tuft near middle. Upper and lower head hairs single. Comb of eighth segment a few scales in a single row. Anal segment slightly longer than wide, ringed by the plate. Air tube short, less than 2 × 1; pecten reaching middle of tube; tuft beyond the pecten.

According to Dyar (14) larvae of *Aedes atlanticus* develop in temporary ground pools. King, Bradley, and McNeel (40) state that this species is a vicious biter and is usually associated with *A. infirmatus* and other woods species. I have a single record of a female caught biting in a woodland in Greene County during November, 1937.

AEDES ATROPALPUS Coq.

Female Characters: A medium sized mosquito. Proboscis long, slender and brownish-black. Occiput black and clothed with dense yellowish-white scales, narrow and erect in center, others broad and curved. Mesonotum black, clothed centrally with narrow dark brown scales, sides and margins with yellowish-white scales. Abdomen black with a narrow basal band of white scales on each segment except the last. Wing scales dark except for a short distance on basal edge of costa where the scales are white. Legs slender and black scaled; femora black with white tips on underneath side at base and entire apex; tibiae black but white at base and apex; hind tarsi black with narrow white rings on both ends of joints, last segment entirely white; mid tarsi with markings usually obsolete on last two joints and apex of third joint, fore tarsi with markings obsolete on last three joints.

Description of Larva: Head rounded in front. Antennae moderately small, rather uniform in size, sparsely spined all over, tuft of two to four hairs near the middle. Both upper and lower head hairs single. Ante-antennal tuft of three to five hairs. Lateral comb of eighth segment made up of many scales in a patch; single scale rounded at apex and fringed with teeth of about equal length, terminal five teeth somewhat larger. Air tube short and stout, less than 2 × 1 and uniformly tapering beyond the base. Pecten reaching almost to tip of air tube; distal two to five teeth of pecten widely spaced and larger; multiple hair tuft about the middle of the air tube and placed well within the pecten. Single pecten tooth long and spine-like and with one to four lateral teeth. Anal segment about as long as wide; dorsal plate reaching almost to the middle of the side; dorsal tuft a brush and single hair on either side; ventral tufts well developed but sparse; lateral hair small and single. Anal gills broad and long, with very distinct tracheae.

This species, which is distributed throughout certain areas in the Eastern United States and is recorded from Arizona and New Mexico, was first taken by the writer in Arkansas during September, 1938. Larvae and pupae were collected from rock holes in the stream bed of Cedar Creek, a small mountain stream in the Petit Jean State Park on Petit Jean Mountain in Central Arkansas. The upper rim of this mountain has an elevation of somewhere between 1000 and 1100 feet and the elevation of that portion of Cedar Creek where active breeding of *A. atropalpus* was found ranged between 900 and 1000 feet.

Larvae, which were mostly in the fourth stage, and pupae were abundant in rock holes and depressions in the rock bed of Cedar Creek on September 13, 1938, the time of the first visit of the writer to this area. Most of these holes were small, ranging from six to eighteen inches in diameter and from three to six inches deep. Heavy mosquito production was found in practically every rock hole examined except some of the larger rock holes having minnows present. In several of the rock holes, larvae of *Anopheles punctipennis* were taken along with larvae of *A. atropalpus*. Forty-one rock holes containing larvae or pupae or both larvae and pupae were counted in a portion of the stream bed measuring approximately thirty feet by fifty feet. Algae were present in most of these holes and several mosquito larvae were found with tufts of filamentous algae extending from the thorax and abdomen.

A second visit was made to this same area on September 16, 1938. At that time most of the brood found on the first visit had passed on to the pupa and adult stages. However, first and second stage larvae of a second brood were found in several of the rock holes. Recent observations indicate that there may be a hatching of eggs following each filling of the rock holes by rainfall. According to Howard, Dyar and Knab (34), the eggs of this species are

laid on the sides of the rock just above the surface of the water and pass through the winter glued to the rocks. Larval production depends upon filling of rock holes by rainfall or overflow during the breeding season. Production is usually heavy during the spring season, light during the summer, and heavier again during the fall.

Adult males and females of this species were taken about midday underneath rock ledges which were located from fifty to one hundred fifty yards from the breeding area. One male was taken resting and another was taken in flight. Several females were taken while biting. The females of *A. atropalpus* are fierce biters; however, little pain can be felt during probing. Females can be induced to feed while in a collecting tube and will take a full meal at one sitting.

Due to the specialized type of breeding habits and short flight range of this species, they are probably of little economic importance in Arkansas except near heavy production areas. Jakmauh (35) reports that *A. atropalpus* has been shown to be able to transmit the virus of equine encephalomyelitis to experimental animals in Massachusetts.

AEDES BIMACULATUS D. and K.

Female Characters: A medium to large, light brown colored mosquito. Prosboscis long, clothed with light brown scales, dark at tip. Mesonotum light brown, clothed with golden scales, a black spot extending above and in front of each wing. Abdomen clothed with brown and yellow scales. Wing scales mostly narrow and yellow to brown in color. Femora yellow scaled, apices black scaled; tibiae light brown scaled, tips black; tarsi light brown scaled, distal portions usually dark scaled.

Description of Larva: (Dyar) "Head rounded, sides bulging. Antennae small, slender, a tuft at middle. Upper head hairs single, lower double, ante-antennal tuft multiple. Comb of eighth segment of about thirty scales in a patch. Air tube 2½ × 1; pecten reaching beyond the middle with detached teeth outwardly, much exceeding the large multiple tuft. Anal segment ringed by the plate."

According to Thibault (55), *Aedes bimaculatus* is rare in Arkansas and confined to particular localities. The adults have been found about dwellings and open porches. The species can be easily recognized by the bright yellowish integument and vestiture.

Aedes bimaculatus was reported from Pulaski County by Thibault on September 23, 1909. This species has not been taken by the writer in Arkansas.

AEDES CANADENSIS Theob.

Female Characters: A medium sized mosquito. Proboscis slender and brownish-black. Mesonotum clothed with rich brown velvety scales. Abdomen dark, segments sometimes with basal bands of white. Wings entirely dark scaled. Tarsi banded with white both basally and apically, last tarsal segment entirely white.

Description of Larva: Head slightly wider than long. Antennae shorter than head. Both upper and lower head hairs multiple. Comb of eighth segment of many scales in a patch. Anal segment slightly longer than wide, not completely ringed by the plate. Air tube approximately 3 × 1; pecten on basal third; multiple tuft near middle.

Larvae of *A. canadensis* develop principally in woodland pools; however, they are frequently found in other temporary bodies of water, including town ditches. The production of these mosquitoes is limited mostly to March, April and May in Arkansas.

The females are fierce biters and are frequently encountered in large numbers in woodlands near their breeding areas during the spring season. Females also feed on cold blooded animals, including turtles. *Aedes canadensis* is well distributed over Arkansas where favorable breeding conditions are present. The mesonotum of this species is entirely reddish-brown and the tarsi have white rings on both ends of joints.

AEDES CINEREUS Meigen

Female Characters: Mesonotum with narrow reddish-brown curved scales. Abdomen bronzy brown, segments with narrow light bands which widen laterally. Wing scales narrow, all dark. Legs blackish-brown.

Description of Larva: (Dyar) "Head rounded, bulging at sides. Antennae large, as long as the head, tuft near the middle. Head hairs and ante-antennal tuft all multiple, in tufts of five to twelve. Comb of eighth segment of about ten scales in a double row. Air tube 4 × 1, a little tapered outwardly; pecten reaching beyond the middle, last three teeth widely detached, followed by a small three haired tuft. Anal segment longer than wide, plate reaching near the ventral line."

This is primarily a Northern species, the larvae of which develop from overwintering eggs in woodland pools. Matheson (46) states that *A. cinereus* is apparently single brooded and that the females are vigorous biters. Both males and females of this species have short palpi.

Thibault (55) states that the adults of *Aedes cinereus* were abundant in woods and grass and about dwellings from April to June near Scott, Arkansas. According to Mail (45), this is a mountain species in Montana and has not been taken on the plains.

AEDES DUPREII Coq.

Female Characters: (Dyar) "Proboscis moderate, dark brown. Mesonotum dark brown, with broad median silvery line the whole length. Abdomen black above with lateral basal segmental triangular white spots. Wing scales narrow, dark. Legs black and bronzy reflections."

Description of Larva: Head slightly wider than long. Antennae small and much shorter than head. Upper head hairs double or triple, lower single. Comb of eighth segment with a single row of scales. Anal segment short and ringed by the plate, anal gills very

long, with prominent tracheae. Air tube approximately 4 × 1; pecten on basal third of tube; multiple tuft beyond pecten.

Aedes dupreii is a summer species which according to Dyar (14) develops in temporary rain pools and remains long at the bottom, hiding among rubbish and leaves. The larvae have extremely long anal gills.

Aedes dupreii was reported by Thibault (55) as a rare mosquito in Arkansas. This species has not been taken by the writer since 1937 in the State.

AEDES HIRSUTERON Theob.

Female Characters: A medium to large sized mosquito. Proboscis black. Mesonotum with broad median longitudinal stripe of golden scales, sides creamy-white. Abdomen black above with narrow white basal segmental bands which widen to form large lateral segmental spots. Wing scales dark brown, almost black. Legs dark brown and black; femora pale.

Description of Larva: (Dyar) "Head rounded, bulging at sides. Antennae moderate, a tuft near the middle. Upper head hairs triple, lower double; ante-antennal tuft multiple. Comb of eighth segment of many scales in a patch. Anal segment about as long as wide, dorsal plate reaching near the ventral line. Air tube 3 × 1; pecten reaching the middle, followed by a hair tuft."

According to Thibault (55), *Aedes hirsuteron* breeds in transient grassy pools in fields and thickets during March, April and May, and after rains throughout the summer.

Aedes hirsuteron is an eager biter, attacking in woodlands and thickets. Thibault (55) states that they do not enter dwellings.

The mesonotum of the female has a golden-brown median stripe and the sides are pale scaled throughout their full length. I have a single female specimen of *A. hirsuteron* which was collected while biting in a woodland in Crittenden County, during May, 1938.

AEDES INFIRMATUS D. and K.

Female Characters: A medium sized mosquito. Proboscis brown. Mesonotum golden-brown with wide median longitudinal stripe of white scales extending just beyond the middle. Abdomen dark brown, almost black, lateral segmental spots present. Wing scales narrow and dark brown. Legs brown; femora pale beneath.

Description of Larva: Head wider than long. Antennae shorter than head. Upper and lower head hairs single. Comb of eighth segment of many scales in a patch. Anal segment about as wide as long and ringed by the dorsal plate. Air tube 3 — 4 × 1; pecten reaching beyond middle of the tube; multiple tuft beyond the pecten.

Matheson (46) claims that this species breeds in temporary rain pools. Thibault (55) reported that the adults of *A. infirmatus* were encountered in woods and thickets and sometimes about dwellings near Scott, Arkansas, where

they were abundant after rains. They are said to be persistent biters, and very annoying when abundant. This mosquito has a wide stripe of silvery scales ending just back of the middle of the mesonotum.

AEDES SOLLICITANS Walker

Female Characters: Proboscis black with wide band of white near middle. Mesonotum clothed with golden scales. Abdomen dark with median longitudinal stripe and wide basal segmental bands of yellowish-white scales. Wings clothed with black and white scales, black scales predominating. Legs clothed with black and yellow scales; hind tarsi with wide basal white bands, first segment with band of yellow scales near middle, last segment entirely white; fore and mid tarsi with first three segments with basal bands of white, last segment of mid tarsi white.

Description of Larva: Head slightly wider than long. Antennae small with multiple tuft near middle; preantennal hairs multiple. Both pairs of head hairs single. Comb of eighth segment of several scales in a patch. Anal segment shorter than wide and ringed by the plate. Air tube stout, less than 2 × 1; pecten with evenly spaced teeth reaching the middle of the tube; multiple tuft beyond the pecten.

Both *A. sollicitans* and *A. taeniorhynchus* have been collected from the LePile Creek and DeLutre Bayou areas in Union County and the Snow Hill Community in Ouachita County in Arkansas since 1937. These two species are common in areas affected by the dumping of salt water from oil wells into creeks and lowland areas. Overflows have carried salt water into depressions along the streams for several miles. Evaporation of the salt water has provided sufficient concentration of the salt in the soil over large areas to provide excellent conditions for development of these larvae in temporary pools formed by rains.

The female deposits her eggs in shallow depressions which become filled with water during rains or by overflows. Larvae are numerous in these depressions for several days after a rain when temperature conditions are favorable. After heavy rains larvae can be found in the main channels of the creeks but these are probably carried out of the temporary pools where they are hatched. The water has too much salt for the development of many predators, therefore the production of adult mosquitoes is usually heavy. Larvae and adults taken during the spring and early summer months were mostly *A. sollicitans; Aedes taeniorhynchus* were dominant during the late summer and fall months.

The females are fierce biters, frequently attacking in bright sunlight at mid-day. After rains the adults are sometimes so numerous that it is almost impossible to walk through woodlands and thickets in the affected areas. Most of the adults encountered were close to the breeding areas and specimens are rarely taken more than a mile beyond

the areas affected by the salt water. Residents of the LePile Creek area claimed that 1937 and 1938 were featured with the worst plagues of these mosquitoes in the entire history of the development of the oil industry in that community.

AEDES TAENIORHYNCHUS Wied.

Female Characters: *Aedes taeniorhynchus* is a somewhat smaller sized mosquito than *A. sollicitans*. Proboscis black with white band at middle. Mesonotum clothed with golden scales. Abdomen black with small basal segmental bands of yellowish-white scales. Wings clothed with brownish-black scales. Legs dark; hind tarsal segments with basal bands of white, last segment entirely white; fore and mid-tarsi with first three segments with basal bands of white, last two segments black.

Description of Larva: Head slightly longer than wide. Antennae small, shorter than head, small tuft near middle. Both pairs of head hairs single. Comb of eighth segment of several scales in a patch. Anal segment wider than long and ringed by the dorsal plate. Air tube stout, less than 2 × 1; pecten reaching near the middle of the tube, teeth evenly spaced; multiple tuft beyond the pecten.

The breeding habits of *A. taeniorhynchus* and *A. sollicitans* appear to be very similar in Arkansas, with the exception that the production during the summer and early fall months is mostly *A. taeniorhynchus*. *Aedes sollicitans* are usually more numerous during the spring and early summer months. Scrapings of sand were taken from two shallow depressions in the valley of LePile Creek during September, 1938, and placed in pint sealing jars. Water was added to these jars and two days later two larvae appeared in one jar. One was reared through, with the emergence of a female *A. taeniorhynchus*.

The habits of *A. taeniorhynchus* are very similar to those of *A. sollicitans* in these areas in Arkansas. Females are fierce biters, usually attacking in large numbers in woodlands and thickets near their breeding places.

Aedes taeniorhynchus has been taken in LePile Creek and Bayou deLutre areas in Union County and in the Snow Hill community in Ouachita County, Arkansas, since 1937.

AEDES THIBAULTI D. and K.

Female Characters: Medium to large sized mosquito. Proboscis black, lightly clothed with brown scales. Mesonotum with median broad black stripe widening on posterior half of mesonotum to cover the entire dorsal surface; long golden scales on sides. Abdomen bluish-black above, lateral spots present. Wing scales narrow, dark brown. Legs black; femora with white spots at apices, underneath portion pale scaled.

Description of Larva: Head rounded, bulging at sides. Antennae nearly as long as head, a tuft near middle. Upper and lower head hairs multiple. Comb of eighth segment of many scales in a triangular patch. Anal segment slightly longer than wide, dorsal plate reaching well down the sides. Air tube approximately 3 × 1; pecten reaching the middle, followed by a hair tuft.

There was very little known of the breeding habits of *A. thibaulti* until Bradley found the larvae in a ground pool under a tree near Mound, Louisiana, in 1924. This mosquito breeds in tree holes or stump holes (pl. 9, E) in marshy areas subject to flooding. The larvae are usually found in the hollow bases and root cavities of Sweet Gum and Tupelo Gum trees. I have examined hundreds of tree cavities in flooded marshes during 1939 and 1940 and have collected larvae from the cavity of one other kind of tree on one occasion, and this was a Cypress tree cavity in a marsh near Little Rock. This mosquito certainly breeds in a tree hole of a specific sort and after an examination of hundreds of trees in marshes where *A. thibaulti* were plentiful, I was impressed with the fact that very few trees other than Sweet Gum and Tupelo Gum provide conditions similar to those in which larvae were developing.

A marsh area near Little Rock where *A. thibaulti* production has been watched closely by the writer during 1939 and 1940 was visited on December 30, 1940. The marsh had been flooded recently, causing water to stand in tree cavities (pl. 9, E). A total of fourteen tree cavities containing standing water were examined. Third and fourth stage larvae of *A. thibaulti* were found in thirteen of these tree cavities. Larvae were also plentiful underneath one partly submerged log, which was located approximately one hundred feet from a tree cavity. A total of 74 larvae were taken in a single dip made with an ordinary dipper from one tree cavity during the inspection made on December 30.

An inspection was made of tree cavities in this marsh again on January 31, 1941, and eight of twelve cavities examined yielded fourth stage larvae of *A. thibaulti*.

I have found two broods developing in a single tree hole on several occasions. Larvae and pupae remain for the most part in the hollow bases of roots where they are not subjected to much light and are seldom collected in large numbers in the trunk cavity where strong light is present.

The adults of this species are usually encountered in thickets and woods during March, April and May, and are fierce biters, attacking at mid-day. They are somewhat wary about feeding and will frequently fly around for several minutes apparently seeking a favorable place to take a blood meal. The female is difficult to capture during this procedure but is easily captured after feeding has begun. A slight pain can be felt at the time the proboscis is entering the skin but only a slight irritation remains after feeding has been completed. Hollow stumps and trees in marshy areas near breeding places are favorite resting places for adults.

Aedes thibaulti is rather general in its distribution throughout Central and Eastern Arkansas where favorable breeding conditions are found.

AEDES TORMENTOR D. and K.

Female Characters: Proboscis moderate, dark brown. Mesonotum dark brown, with a median narrow silvery line. Abdomen black above with lateral basal segmental triangular white spots. Wing scales narrow, dark. Legs black with bronzy reflections.

Description of Larva: Head rounded, bulging at sides. Antennae rather long, a tuft at middle. Head hairs single. Comb of eighth segment of about nine scales in a straight row. Anal segment ringed by the dorsal plate. Air tube about 2½ × 1; pecten reaching three-fourths the length of the tube, enclosing a small four-haired tuft.

Aedes tormentor was reported from Scott, Arkansas, by Thibault on August 31, 1908. This species has not been taken by the writer in Arkansas since 1937. According to Dyar (14), larvae of *A. tormentor* develop in temporary rain pools. Adults are said to be found mostly in woods and thickets after rains and sometimes about dwellings. They are persistent biters.

AEDES TRISERIATUS Say

Female Characters: A medium sized mosquito. Proboscis long, slender and black. Mesonotum dark brown dorsally and with sides silvery-white. Abdomen dark above and with a metallic luster; lateral segmental spots silvery-white. Wings dark scaled. Legs very dark.

Description of Larva: Head slightly wider than long. Antennae small, shorter than the head, single hair near the middle. Upper head hairs single, lower pair of two or three hairs. Anal segment about as wide as long, dorsal plate reaching approximately half way to ventral side. Air tube stout, about 2 × 1; pecten reaching middle, teeth evenly spaced; tuft a single hair beyond the pecten.

The eggs are deposited by the female in tree holes, stumps, and other containers. Larvae have also been collected in Arkansas from tin cans and discarded toilet flush basins in which leaves had accumulated.

The adults frequent woods near their breeding places. The female is a fierce biter, attacking during the day in woodlands or around homes located near their breeding places. This species is frequently encountered in dry woods during the summer when ground water is scarce. The bite of this mosquito is very painful and the swelling and irritation often lasts for several days.

Aedes triseriatus appears to be distributed throughout Arkansas where favorable breeding conditions are found. This species has patches of conspicuous silvery-white scales on the sides of the thorax.

AEDES VEXANS Meigen

Female Characters: A small to medium sized brown mosquito. Proboscis slender and black. Mesonotum clothed with brown scales which fade to yellowish-white in the antescutellar region. Abdomen

with basal bands of white with distinct notches above. Wings clothed with brown scales. Legs dark; tarsi with narrow basal white bands.

Description of Larva: Head somewhat wider than long. Antennae about as long as head; multiple tuft near the middle. Upper head hairs three or four, lower double. Comb of eighth segment about as wide as long; ringed by the dorsal plate. Air tube approximately 3 × 1; pecten reaching middle, distal two teeth widely spaced; multiple tuft beyond the pecten.

Aedes vexans pass the winter in the egg stage. According to Mail (45) this species is single brooded in Montana and the fact that adults appear from May until August is due to irregular hatching of the eggs. Larvae have been collected in Arkansas from April through November. Larvae of this species have been collected from temporary and semi-permanent pools in cleared fields, meadows, borrow pits, bayous, town ditches, cow tracks, and roadside ditches in Arkansas. In one instance larvae were collected by the writer from a woodland pool. Suitable areas for the production of this species are more numerous in Central and Eastern Arkansas than in the Northwestern part of the State.

The production of *A. vexans* is usually heavy where favorable breeding conditions are present in Arkansas. During August of 1938, *A. vexans* became very annoying in the vicinity of the Riverside Golf Club in Little Rock, where they were developing in temporary pools on the playing field. Adults became well distributed over the City of Little Rock during that period. According to Hearle (25) this species can migrate ten miles or more. The adults have a V-shaped notch in the middle of the posterior border of the white abdominal bands and narrow bands of white scales on the hind tarsi.

Genus PSOROPHORA Robineau-Desvoidy

The larvae of the mosquitoes of this genus in Arkansas live in temporary ground pools formed by rains. The eggs are laid singly in moist or dry depressions where water is likely to collect and remain for several days following rains. The adult females of the larger species are severe biters. Nine species of this genus are recorded for the State.

PSOROPHORA CILIATA Fab.

Female Characters: A large mosquito. Proboscis light brown, clothed with broad black scales. Mesonotum black, a median longitudinal stripe of golden scales; bordering this median stripe is a bare area followed by a stripe of erect black scales; this black stripe is followed by another bare area; the lateral margins are covered with broad gray scales. Abdomen clothed with yellowish-white and brown scales. Wings clothed with dark scales. Legs large; femora yellow, mid and hind tibiae clothed with long erect black scales, fore

tibiae lightly clothed with shorter black scales; hind tarsi with broad basal white bands, rest clothed with long black scales erect on first two segments; mid and fore tarsi with first joint mostly yellow, other segments with basal bands of white.

Description of Larva: Head slightly longer than wide. Mouth brushes of stout prehensile hairs, slightly hooked at tips and a row of teeth along side of each. Antennae much shorter than head and a single hair near distal end. Upper and lower head hairs single. Comb of eighth segment a row of thorn-like scales preceded by a patch of small scales. Anal segment ringed by the dorsal plate; lateral hair of anal segment branched three or four times near the base. Air tube approximately 4 × 1; pecten a row of teeth prolonged into hairs and reaching about the middle of the tube; tuft a single hair arising beyond the pecten.

The female of *P. ciliata* deposits her eggs on the ground in depressions where water will likely remain for several days after rains. The larvae develop rapidly. Larvae of *P. ciliata* are predacious, feeding on other mosquito larvae with similar breeding habits such as *P. columbiae*. Larvae are seldom found in sufficient numbers to be of much importance in the control of mosquitoes with which they are associated in their immature stages. This species is frequently encountered from June through September in Arkansas.

The females are vicious biters, attacking any time during the day when their haunts are invaded. They are frequently encountered in open rice fields but more often around the borders of the fields where some shade is present. The female inflicts a painful injury and can bite through summer clothing with ease.

Psorophora ciliata appears to be distributed over most of Arkansas but is more numerous in lowland areas where temporary pools persist after rains. This species is common in the rice fields where conditions are favorable for their development throughout their entire breeding season.

PSOROPHORA COLUMBIAE D. and K.

Female Characters: A medium to large sized mosquito. Proboscis with apical and terminal portions black scaled, middle portion yellowish-white scaled. Mesonotum black, sparsely covered with light brown scales. Abdomen bluish-black, sprinkled with white scales. Wings speckled with brown and white scales, brown predominating. Legs long; femora with a narrow white ring before apex, tibiae black with many small patches of creamy-white scales on outer surface; tarsal segments black with wide basal bands of white, first tarsal segment with broad white band, last two tarsal segments of fore leg and last segment of middle leg entirely black.

Description of Larva: Head wider than long. Antennae shorter than head, multiple hair tuft just beyond the middle. Upper and lower head hairs multiple. Comb of eighth segment of six scales in a single row. Anal segment slightly longer than wide and ringed by the plate. Air tube large, inflated, and approximately 3 × basal width; pecten a few strong widely spaced teeth, tuft of tube small and beyond the pecten.

Females of *P. columbiae* deposit their eggs on the ground in depressions where water is likely to remain after rains. The favorite breeding areas in the rice field country are depressions outside the irrigation ditches which become filled by seepage and overflow when water is pumped into the irrigation system. The irrigation ditches themselves are excellent places for depositing of eggs after water is drawn off, and if allowed to become dry at frequent intervals, they may become heavy production areas for these temporary pool breeders. Larvae of *P. columbiae* were found by the writer in large numbers in the irrigation ditches in a rice field near Lonoke, Arkansas, on July 15, 1938.

Females will readily deposit eggs on damp cellucotton in small oviposition vials. A single female collected and fed on August 22 deposited eggs in an oviposition vial on August 25. July, August and September are usually the months of heavy production of this species.

The females are vicious biters, attacking during both day and night. Adults are frequently encountered in large numbers around the edges of rice fields, where they may be found resting on the grass or underbrush. Persons walking through these areas are often practically covered from head to feet with hungry mosquitoes. Adults are frequently found resting in buildings associated in this respect with *Anopheles quadrimaculatus.*

This is a common mosquito in areas where temporary pools form during rainy seasons, providing suitable conditions for the development of the immature stages. They are present in large numbers throughout their entire breeding season in the rice fields of Arkansas where they are commonly known as "rice field mosquitoes."

PSOROPHORA CYANESCENS Coq.

Female Characters: A medium to large sized mosquito. Proboscis black with bluish reflections. Mesonotum black, clothed dorsally with yellowish-brown scales, gray on sides. Abdomen dark with bluish reflections above, apical segmental bands of yellow scales. Wing scales brownish-black. Legs long; femora yellowish; tibiae and tarsal segments black with bluish or violet reflections.

Description of Larva: (Dyar) "Head wider than long. Antennae stout, long, but no longer than head. Head hairs single; anteantennal tuft triple hairs. Comb of eighth segment of five scales on a weakly chitinized area. Air tube strongly inflated, 3 × basal width; a small pecten of four teeth on base of tube. Anal segment longer than wide, ringed by the dorsal plate."

Adults of this species have been frequently collected during the summer months by the writer in Central and Eastern Arkansas since 1937. Females are usually collected biting in open woods or thickets near suitable breeding

areas. Eggs are deposited by the female on the ground and larvae develop in temporary rain pools.

Psorophora cyanescens are most numerous after rains during July and early August. The females are fierce biters, attacking any time during the day in and near thickets. *Psorophora cyanescens* were present in large numbers on the Riverside Golf Course near Little Rock during early August of 1938, making it almost impossible to play four holes which were near a low woodland area. Females begin feeding immediately after lighting and will feed until they are barely able to fly.

PSOROPHORA DISCOLOR Coq.

Female Characters: A medium sized mosquito. Proboscis black at base and tip, broad band of pale scales at the middle. Mesonotum dark brown and clothed with fine golden scales. Abdomen dark, a mixture of pale scales present. Wings clothed with both black and pale scales, black scales forming prominent patches. Legs pale brown with few black scales; tarsi with pale bases and dark tips.

Description of Larva: Head slightly wider than long. Antennae very large with middle portion inflated, two large spine-like bristles on outer third. Upper and lower head hairs long and single. Comb of eighth segment of six large joined scales on a chitinous plate. Anal gills long and tracheate. Air tube small, approximately 3 × 1; pecten reaching the middle, large multiple tuft beyond the pecten.

Larvae of *P. discolor* have been collected by the writer in six communities in Arkansas since 1937. Breeding occurs from June to October. My collections were taken from temporary and semi-permanent pools consisting mostly of ditches and a small borrow pit. The larvae have a habit of lying on their backs on the bottom of the collection jars. Larvae have been observed to fasten themselves to the sides of the jar by means of the air tubes.

Adults have been taken in a light trap on several occasions by the writer. *Psorophora discolor* are seldom present in large numbers in Arkansas and are therefore of little economic importance.

PSOROPHORA FEROX Wied.

Female Characters: A medium sized mosquito. Proboscis brownish-black Mesonotum dark and clothed with a mixture of brown and white scales. Abdomen black with violet reflections above; lateral segmental spots of yellowish-white scales at apices. Wings clothed with dark scales. Legs long and slender; femora pale underneath and black with violet reflections above; apical portion of tibiae and first two tarsal segments of hind legs with long outstanding scales, giving a shaggy appearance; last two tarsal segments of hind legs white.

Description of Larva: Head wider than long. Antennae large, longer than head. Both pairs of head hairs usually double. Comb of eighth abdominal segment of seven or eight scales in a single row. Anal segment longer than wide and ringed by the dorsal plate. Air tube large, inflated, 3 to 4 × 1; pecten of three to four teeth on basal fifth of tube; tuft of air tube very small.

Larvae have been found in temporary and semi-permanent pools on several occasions in Arkansas since 1937 by the writer. Larvae were associated with those of *Aedes vexans, Culex salinarius, Culex apicalis,* and *Anopheles punctipennis* in one breeding place in Fayetteville during August, 1940.

The females of *P. ferox* are fierce biters, attacking during the day in woodlands and thickets. Thibault (55) states that they are sometimes taken inside houses but more frequently in the woods, and that they are sometimes troublesome to live stock.

PSOROPHORA HORRIDA D. and K.

Female Characters: A medium sized mosquito. Proboscis black. Mesonotum black with broad white scales on sides. Abdomen bluish-black above, yellowish-white triangular lateral spots. Wings clothed with narrow brown scales with purple reflections. Legs black with purple reflections; last two segments of hind tarsi white.

I have records of adult collections of *P. horrida* from Union County on September 23, 1937, and from Miller County on July 9, 1940. I have never encountered the larvae of this species.

PSOROPHORA HOWARDII Coq.

Female Characters: A large mosquito. Proboscis bluish-black. Mesonotum brown and black, a long patch of white scales on each side. Abdomen bluish-black. Wing scales dark brown and moderately narrow. Femora yellow scaled, apices with outstanding dark scales; tibiae clothed with dark scales with blue reflections; tarsi dark scaled with blue reflections, first two tarsi of hind legs with pale basal bands.

Description of Larva: Head wider than long; mouth brushes of stout prehensile hairs each with a row of comb-like teeth. Antennae small, shorter than head. Head hairs single. Comb of eighth segment of many scales in a patch. Lateral hair of anal segment single, sometimes forked well beyond base. Air tube about 4 × 1; pecten reaching middle of tube with numerous teeth prolonged into hairs; tuft a single hair beyond pecten.

Psorophora howardii are found under similar conditions to those favoring the production of *P. ciliata* which is a similar species. These mosquitoes are seldom as numerous as *P. ciliata* in Arkansas.

The eggs of *P. howardii* are deposited in depressions where water will likely remain after rains. The larvae are predacious, feeding on mosquito larvae and other small aquatic animal life with which they are associated. Larvae of this species are seldom encountered in sufficient numbers to be of much importance in the control of associated species of mosquitoes. A female collected in Little Rock, Arkansas, on August 22 and fed during the same day deposited her eggs in a small oviposition vial on August 25.

The females are fierce biters, rivaling *P. ciliata* in this habit. Adults are usually found near their breeding places, where they will attack at mid-day.

PSOROPHORA SIGNIPENNIS Coq.

Female Characters: A medium sized mosquito. Proboscis dark brown at base and on terminal portion, a wide band of yellow scales on middle. Mesonotum brown, clothed with golden scales on median surface, scales paler on sides. Abdomen a mixture of black and white scales. Wings with dark brown and white scales, black spots on apical half of costa. Legs with a mixture of brown and white scales; tarsal segments with wide basal bands of yellowish-white scales.

Description of Larva: (Dyar) "Head wider than long. Antennae about as long as the head, a multiple tuft at middle. Head hairs single. Comb of eighth segment of six large scales on a weak chitinization. Anal segment longer than wide, ringed by the dorsal plate. Air tube inflated, about 3 × basal width; a small pecten of four spines at base of tube."

According to Dyar (14), *P. signipennis* is adapted to arid conditions where rains are infrequent and water disappears rapidly. The larvae occur in small transient rain pools.

I have only two records, consisting of four adult specimens, of this species for Arkansas since 1937, and these were from light trap collections taken on consecutive nights at Dyess, Arkansas, during August, 1938.

PSOROPHORA VARIPES Theob.

Female Characters: A medium sized mosquito. Proboscis long, slender and black. Mesonotum black, clothed with narrow brownish-black scales arranged to form a broad longitudinal stripe; a broad patch of silvery scales along the sides. Abdomen black above with violet reflections. Wings clothed with narrow dark scales. Legs long and clothed with black scales; base and underneath portion of femora with yellow scales; tarsi bluish-black excepting penultimate joint of hind tarsi which is entirely white.

Description of Larva: (Dyar) "Head rounded, wider than long. Antennae as long as the head, a long tuft beyond the middle. Head hairs in twos, long ante-antennal tuft multiple. Comb of eighth segment of six separated scales. Anal segment longer than wide and ringed by the plate. Air tube inflated, about 3 × basal width; four sparse pecten teeth near base."

The female of *P. varipes* deposits her eggs on the ground over areas likely to be flooded during the rainy season. There appears to be a single generation of this species in Arkansas. Hatching of the eggs apparently depends upon the area being flooded when temperature conditions are favorable for their development. After taking a blood meal, the female will readily deposit eggs on damp cellucotton in oviposition vials. A single female fed on May 2 deposited 22 eggs on May 6. This same female was fed again on May 6 and deposited 61 eggs on May 10. I have never taken the larvae of this species.

The females of *P. varipes* are vicious biters, attacking any time during the day. The females are sometimes encountered in swarms in woodland areas, especially in creek bottoms after the recession of flood waters during the spring months. In a woodland along a creek which had recently been flooded in Lee County, these mosquitoes were encountered in such numbers on May 2, 1938, as to make it unbearable to persons attempting to walk through the woodland. Females are sometimes encountered in woodlands throughout the summer season. The latest seasonal record I have for this species is September 6, 1938.

Genus THEOBALDIA Neveu-Lemaire

The two species of this genus found in Arkansas closely resemble *Culex* in the egg, the larva, and the adult stages. They are apparently of very little economic importance.

THEOBALDIA INORNATA Will.

Female Characters: A large mosquito. Proboscis with a mixture of dark brown and white scales. Mesonotum brown and lightly clothed with golden scales. Abdomen brown above with broad basal segmental bands of yellowish-white scales which widen laterally. Wings very large and lightly clothed with dark scales, anterior veins with few white scales. Legs long, clothed with a mixture of brown and yellowish-white scales.

Description of Larva: Head wider than long. Antennae small, much shorter than head, multiple tuft near middle. Head hairs multiple, preantennal hairs multiple. Comb of eighth segment of many scales in a patch. Anal segment about as wide as long, ringed by the dorsal plate. Air tube about 2½ to 3 × 1; pecten a row of strong teeth on basal portion of tube followed by a row of long hairs; a pair of large tufts arising on base of tube.

Larvae of *T. inornata* have been collected during November, December, January, February, March, April and May in Arkansas by the writer. Larvae have been taken in borrow pits, roadside ditches, temporary pools, woodland pools, and town ditches. They are frequently very numerous in town ditches containing filth. On one occasion heavy breeding was found in a ditch fed by a cesspool drain. The eggs are laid in rafts which float on the water. The heaviest breeding of this species occurs during February, March, and early April in Arkansas. Larvae of this species are often mistaken for those of *Culex quinquefasciatus* by mosquito inspectors in towns, and in several instances control measures have been applied against these mosquitoes.

According to Mail (45), the female avoids dwellings and does not readily attack man. They seem to prefer larger animals and become troublesome to cattle in woodland areas during the spring in Montana. I have never been able to induce females of this species to take a blood

meal in captivity. Several adults were taken in a New Jersey mosquito trap on the Camp Robinson reservation near Little Rock during the nights of October 7 and 8, 1940.

THEOBALDIA MELANURA Coq.

Female Characters: (Dyar) "Female proboscis slender. Mesonotum with narrow reddish-brown scales. Abdomen blackish with pale basal segmental bands. Wing scales narrowly ovate or broadly linear, all dark. Legs dark brown."

Description of Larva: (Dyar) "Antennae slender, longer than head, large tuft near tip. Head hairs in tufts. Comb of eighth segment of many long bar-shaped scales in a straight row. Anal segment longer than wide, ringed by the plate. Air tube long, straight, 6 × 1; a small paired tuft near base of tube; a double row of pecten running one-third, a single posterior row of twelve small equal tufts."

Larvae of *T. melanura* are said to develop in small permanent water areas in swamps. Matheson (46) says that the species overwinters as larvae under the ice.

According to Horsfall (32), *T. melanura* were plentiful in Southeastern Arkansas during October and November. This species has not been collected by the writer in Arkansas since 1937.

Genus MANSONIA Blanchard

The females of this genus lay their eggs in rafts upon the surface of lakes containing dense growths of emergent vegetation. After hatching, the larvae attach themselves to the stems and roots of certain types of plants from which both the larvae and pupae obtain their air supply. King, Bradley, and McNeel (40) have described a very successful method of collecting the larvae of these mosquitoes. Only a single species, *M. perturbans*, is reported as occurring in Arkansas.

MANSONIA PERTURBANS Walker

Female Characters: A medium to large sized mosquito. Proboscis black with a broad band of pale scales near the middle. Mesonotum light brown, clothed with a mixture of black and yellowish scales, two median longitudinal bare stripes. Abdomen dark above; basal segmental bands of white scales, these bands narrow or lacking on last few segments of abdomen. Wings with a mixture of broad black and white scales, black scales predominating. Legs long and slender; femora with black and white scales above, pale below, patch of white scales at apices; first joint of all tarsi with narrow basal band and wide band near the middle, all other tarsal segments dark with broad basal bands.

Description of Larva: (Dyar) "Head rounded, strongly transverse. Head hairs in multiple tufts. Antennae long, shaft itself longer than head, large tuft at outer third. Comb of eighth segment of about nine narrow separated scales in a curved row. Anal segment three times as long as wide, ringed by the plate. Air tube short and stout, truncate, one margin produced into a saw, a three haired paired tuft at the middle; two filaments at the truncation before the saw."

According to King, Bradley and McNeel (40), the eggs of this species are deposited in the form of a raft on the surface of the water in marshes containing thick growths of aquatic vegetation. After hatching, the larvae go to the bottom and anchor themselves by means of their air tubes to stems or roots of vegetation. They pass the winter in the larva stage and emerge during the spring and summer.

The females are fierce biters, attacking after dusk and during the early hours of the night. They are able to migrate long distances from their breeding places, and when once established in a lake, where conditions are favorable for their development, they may become a scourge to the community.

Adults of this species have been taken in two areas by the writer in Arkansas since 1937. Two females were taken in a light trap collection at Tillar, Arkansas, during the night of June 14, 1938, and adult females were plentiful in a pump house near a lake in Saline County on June 5, 1940. A female was taken biting in a thicket nearby during mid-day. Adults persisted throughout most of the summer in this latter area.

Genus MEGARHINUS Robineau-Desvoidy

The mosquitoes comprising this genus are large and brilliantly colored. These mosquitoes are characterized by having the proboscis curved downward on the outer half and not fitted for sucking blood. The adults fly during the day and have been observed feeding on nectar of plants. They breed in tree holes, stump holes, and other artificial wooden receptacles. The larvae are predacious and feed principally on larvae of other tree hole breeding species. A single species of *Megarhinus* is recorded for Arkansas.

MEGARHINUS SEPTENTRIONALIS D. and K.

Female Characters: A large, brilliantly colored mosquito. Proboscis with black and violet scales, long and sharply curved downward beyond the middle. Palpi nearly as long as the proboscis. Mesonotum dark brown with median line and sides of gray; blue, green, and violet scales numerous on mesonotum. Abdomen metallic green above, lateral segmental golden spots. Wings lightly clothed with broad purplish scales. Legs dark with numerous purple scales; femora yellowish below; fore and mid-tarsi with second, third and fourth joints white; hind tarsi with fourth and fifth joints white.

Description of Larva: Head about as wide as long. Antennae very small and much shorter than head. Mouth brushes a few stout closely appressed curved rods. Eighth segment without comb scales but with a lateral plate on each side bearing two spine-like hairs on posterior margin. Anal segment about as long as wide and ringed by the plate. Air tube about 2 to 3 × 1; pecten absent, multiple tuft near base.

The larvae develop mostly in tree holes; however, they are frequently taken from artificial wooden containers. A single breeding area seldom yields more than a dozen specimens in one collection. They are often associated with larvae of *Aedes triseriatus, Orthopodomyia signifera,* and *Anopheles barberi* in their breeding places. Larvae develop very slowly and may be kept for several weeks or months before development is completed.

Megarhinus septentrionalis flies by day and feeds on plant juices. The adults are often found resting near their breeding places. On one occasion a female of this species was taken inside my home in Little Rock during the summer of 1938.

Megarhinus septentrionalis appears to be distributed throughout the State in both lowland and upland areas where suitable breeding places are available.

Genus ORTHOPODOMYIA Theobald

The immature stages of the mosquitoes belonging to this genus are usually passed in tree holes and stump holes. A single species is found in Arkansas.

ORTHOPODOMYIA SIGNIFERA Coq.

Female Characters: A small to medium sized mosquito. Proboscis black with longitudinal stripes of white scales. Mesonotum dark brown, nearly black, six narrow longitudinal stripes of white scales. Abdomen black, indistinct white bands on a few of the abdominal segments, lateral segmental spots of white scales. Wings clothed with a mixture of brown and white scales. Legs black with a sprinkling of white scales; hind tarsi with white bands on both sides of joints.

Description of Larva: Head slightly wider than long. Antennae shorter than head. Head hairs multiple. Comb of eighth segment with a row of short scales and a partial second row of long scales; segments seven and eight with large chitinous plates. Anal segment about as wide as long. Air tube approximately 3 × 1; a large multiple tuft near middle of tube; no pecten present.

The immature stages of *O. signifera* are passed in tree holes or stump cavities where water stands over a sufficient period to allow emergence of adults. Larvae may be found almost any time during the year in tree and stump holes. Since this is a tree hole mosquito, its distribution is determined somewhat by the availability of suitable breeding places of this kind.

Adults are frequently found resting near their breeding places. They do not seem to be of much economic importance in Arkansas.

Genus URANOTAENIA Lynch-Arribalzaga

Mosquitoes of the genus *Uranotaenia* can be separated from other genera in Arkansas by the fact that the second submarginal cell is less than half as long as its petiole. The adults are very small and the palpi of both males and females are short. The upper and lower head hairs of the larvae are single, stout, and spine-like.

URANOTAENIA SAPPHARINA Osten-Sacken

Female Characters: A small mosquito. Proboscis long, dark, and enlarged at tip. Mesonotum clothed with brown scales; a narrow median longitudinal line of metallic blue scales extending the length of the mesonotum, a short line of blue scales in front of the root of each wing. Abdomen clothed with brownish-black scales, patches of white scales on some of the segments. Wings with brown scales, metallic blue scales on some of the wing veins, more pronounced on basal parts of veins. Legs brownish-black; apices of femora and tibiae with white scales.

Description of Larva: Head much longer than wide. Antennae much shorter than head. Upper and lower head hairs single and spine-like. Comb of eighth segment a single row of stout teeth on distal edge of a chitinous plate. Anal segment completely ringed by the dorsal plate. Air tube approximately 4 × 1; pecten on basal third; tuft of air tube large and multiple, beyond the pecten.

Larvae of *U. sappharina* are found in semi-permanent or permanent water areas usually containing heavy growths of aquatic vegetation. Larvae of *Anopheles quadrimaculatus* are commonly found associated with those of *U. sappharina*. At first glance larvae may be mistaken for *Anopheles* larvae, since their heads are longer than wide, and they have the habit of floating flat in the water.

Although the larvae are often numerous where suitable breeding conditions are found, the adults are seldom encountered in large numbers. According to Dyar (14), the females will bite under favorable conditions.

Collection records for *U. sappharina* show that this species is present in most areas in Arkansas where *Anopheles quadrimaculatus* are found breeding.

MOSQUITO CONTROL

Our present knowledge of the habits of mosquitoes and information on methods of control support the idea that we must continue our attacks on the larval and pupal stages to successfully combat these insects. Since larval habits as well as adult habits of the different kinds of mosquitoes are often quite different, a knowledge of the habits of the important species is very essential. In order to obtain satisfactory mosquito control for an area, all breeding places within flight range must be found and elimi-

nated or treated in such manner that mosquito production will not take place.

The fact that the different species of mosquitoes differ in their breeding habits must be remembered and the diverse habits must be taken into consideration before control measures can be outlined and applied intelligently.

The application of control measures should always be preceded by a well planned mosquito survey, including the collection and identification of both adult and larval specimens and the careful mapping of important breeding areas of the important species. Preliminary studies of this kind should, if possible, be conducted over a period of at least one year before actual control procedures are placed in operation. Provisions should be made for continuing the collection and identification of specimens as a means of obtaining information on the effectiveness of the control program.

ELIMINATION OF BREEDING PLACES

In any mosquito control program, the elimination of breeding places or the establishment of conditions unfavorable to the development of mosquitoes is of major importance. In considering the control of mosquitoes by eliminating the breeding places, one must understand the diversity of places suitable for breeding of different species, as well as flight ranges and other habits of important species.

Ditching for the purpose of eliminating water areas and providing continuous drainage of marshy areas has had a wide application as a method of mosquito control in Arkansas. Ditching may be a temporary measure of control unless proper maintenance of ditches is provided. There is a definite trend in urban areas toward permanent ditch construction with concrete and stone masonry (pl. 10). Underground drains of tile are being used in many areas. Projects of this nature requiring the expenditure of large sums of money should be preceded by a careful study of the mosquito problem and comprehensive drainage plans prepared by trained engineers.

Filling of marshy lands in and near urban areas is an important means of eliminating mosquito breeding. Valuable land can be reclaimed in this manner for building sites, development of playgrounds, and other useful purposes.

Mosquito breeding can usually be prevented around the home by close examination of the premises during the summer months. Roof gutters should be kept free of debris

to prevent stoppage resulting in accumulations of water which provide ideal conditions for the development of *Aedes aegypti*. Other conditions around the home, such as water in cans, jars, barrels, tubs, flower vases, bird baths, basements, etc., often provide suitable conditions for breeding of both *Culex quinquefasciatus* and *Aedes aegypti*.

LARVICIDES

Under certain conditions permanent mosquito control measures are impractical and temporary measures involving the application of toxic substances causing death of mosquito larvae and pupae must be resorted to at regular intervals.

Several kinds of larvicides are now available, but petroleum oils, pyrethrum mosquito larvicide, and Paris green dust larvicide are materials more frequently used in mosquito reduction work.

Petroleum Oils: Treatment of mosquito breeding areas with petroleum oils is an important method of mosquito eradication. The larvae of our important pest mosquitoes are mostly bottom feeders, coming to the surface to obtain air at certain intervals. Several theories have been advanced to explain the killing action of oils on mosquito larvae. For a long time it was thought that a film of oil served only as a barrier between the larvae and the air, leading to suffocation. This is probably of some importance in the killing of mosquito larvae with oil. Contact of the oil with the body of the larva is also probably of some importance.

Various workers have shown that oil vapors are the principal toxic factors in most petroleum oils. Therefore, toxicity increases with volatility, since the lethal effects are due mostly to volatile gases penetrating the tracheal tissues. Workers have shown that the volatile action of heavy oils is secondary to contact with the body tissues with the oil and the mechanical plugging of the tracheae.

Since the killing of mosquito larvae with oil is due to a combination of several factors, not all oils are satisfactory for mosquito reduction work. A mixture of a heavy oil with a lighter oil is usually more satisfactory for mosquito control than either a heavy oil or an extremely light oil used separately. A mixture of this type offers a combination of long lasting and toxic properties. Light distilled fuel oils are very satisfactory when applications are made from weekly to ten-day intervals. Headlee 1921 states that the best oil for mosquito control is "One that readily forms

a complete homogeneous film when applied to the water surface by a small portable sprayer, and which remains effective for at least two weeks, or better still, for one month."

There is a tendency in several towns and communities to use whatever type of oil is available, such as automobile crank-case oil or a heavy oil, for mosquito reduction work. Without proper straining and treatment crank-case oil does not spread properly, creeps up the stems of vegetation and burns it, is heavy, and is not pleasant to use. The lack of volatility of a heavy oil gives it a low degree of toxicity and therefore is not satisfactory for mosquito control work when used alone. Light distilled fuel oils, used at weekly to ten-day intervals, are satisfactory for mosquito control work because of economical cost and ease of handling in spraying equipment.

It has been observed that some species of mosquitoes and certain stages of mosquito larvae are affected differently by the same oils. The first and second instars of mosquito larvae may depend more upon cuticular respiration than the third and fourth instars and come to the surface less frequently for oxygen. Newly hatched larvae often survive a good oil film for several hours after oiling. This fact must be recognized in planning satisfactory oiling operations. There is also the danger of a highly volatile oil evaporating without producing a good kill.

Pyrethrum Larvicide: For several years mosquito workers have felt that there was a distinct need for some cheap but effective mosquito larvicide which could be used in the place of oil under certain conditions. There has been a growing opposition among sportsmen and others interested in wildlife to the use of oil on certain areas because it is poisonous to fish and waterfowl and is injurious to aquatic plants upon which many types of wildlife depend for food. Often residents object to the use of oil on streams or pools on their premises because of its unsightly appearance and the fact that it stains and burns grass and other marginal vegetation. Oil often causes skin irritations and severe burns to the oiler. Ginsburg (19) states that in order to prevent these injuries one would have to reduce oil to one-tenth the amount necessary to kill mosquito larvae and pupae.

The New Jersey pyrethrum mosquito larvicide developed by Dr. J. M. Ginsburg, Biochemist of the Agricultural Experiment Station, in New Jersey, has proved to be a satisfactory substitute for oil under certain conditions, and is being used extensively in many of the Eastern States. A

formula for the preparation of the emulsion larvicide, adapted from Ginsburg (19), is as follows:

2 gallons kerosene containing pyrethrum extract (equivalent to 1 pound pyrethrum flowers per gallon)
1 gallon water
8 to 10 ounces liquid 40 per cent potash soap

The soap is dissolved in the water and the kerosene containing the pyrethrum is slowly added, with constant mixing with agitators until a cream-like stock emulsion is obtained. After the foam has settled, the emulsion should be stored in tightly closed containers until required. A concentrated pyrethrum extract containing twenty or forty pounds of the pyrethrum flowers per gallon can be purchased for making the stock emulsion. The prepared stock emulsion can also be purchased.

For mosquito control work the concentrated kerosene pyrethrum emulsion should be well shaken, mixed with 10 or 12 parts of water, and sprayed on the mosquito breeding areas at the rate of about 35 to 50 gallons per acre in the same manner as oil. The larvicide can be applied with the ordinary knapsack sprayer equipped with a nozzle for producing a fine mist spray which insures equal distribution on the water surface. The water for mixing can be taken directly from the breeding place, providing it is clear and free from debris and other solids which would clog the nozzle of the sprayer.

The kerosene forms a thin film on the surface of the water. The pyrethrum extract remains incorporated in the oil film and is very toxic. This thin layer of chemicals is sufficiently toxic to kill mosquito larvae and pupae but is not injurious to plants, fish, waterfowl, domestic animals and man. Frequent shaking of the sprayer is necessary to insure proper mixing of the materials while the sprayer is being operated. Pyrethrum larvicide has proved more economical than oil in many states.

Experiments conducted at the New Jersey Agricultural Experiment Station have shown that this larvicide when properly applied is as effective as oil on clear fresh water, ornamental ponds, fish and game preserves, catch basins, and filter beds with little or no scum. It has an advantage over oil of being easily distributed. Instead of carrying ten gallons of oil into the field, the workman can carry one gallon of the emulsion into the field and obtain the water necessary for dilution from the breeding area. Unlike oil, it does not irritate the skin or burn it, and is more pleasant to handle. This larvicide is somewhat less effective

than oil when applied to water covered with heavy vegetation or debris, filter beds with a heavy scum or places where the long lasting quality of an oil larvicide is essential.

Field and laboratory experiments performed by the writer during the summer of 1938 indicate that pyrethrum larvicide gives satisfactory results in the control of both Anopheline and Culicine mosquitoes under most conditions in Arkansas.

Experiments performed by the writer indicate that more time was required for killing pupae than for the larvae of the different species studied. This was true under both field and laboratory conditions. Less time was required to kill Anopheline larvae than such species as *Culex quinquefasciatus, Uranotaenia sappharina, Psorophora columbiae* and *Culex erraticus.* There was no difference observed in the time required for killing the different stages of the larvae of the species studied.

Paris green: Paris green diluted with some inert dust such as hydrated lime and spread over the water surface of ponds and lakes has proved to be an effective larvicide for the control of surface feeding Anopheline mosquito larvae. This poison remains on the surface of the water, killing surface feeders but when used in this manner is not effective against other species of mosquitoes which feed on the bottom. It is possibly not harmful to other forms of aquatic life. When properly applied, the results obtained with this dust larvicide are almost perfect, killing practically 100 per cent of the Anopheline larvae.

For hand dusting, a mixture of approximately ninety per cent hydrated lime and ten per cent Paris green by volume applied at the rate of one-half to three-fourth pound Paris green per acre at seven to ten day intervals has proved very effective for the control of Anopheline mosquito production. The material cost of this dust larvicide is small compared with the cost of most other effective larvicides. For small projects the Paris green and hydrated lime can be mixed by hand. The strength of Paris green has been found to show a considerable amount of variation, therefore the toxicity of each lot should be tested before it is used for general control work.

A crank-type hand duster operated either from the shore or from a boat for distributing Paris green dust mixtures is satisfactory for the control of *Anopheles* mosquitoes in ponds and small lakes in Arkansas (pl. 11, A). LePrince and Johnson (43) demonstrated the application of Paris green for Anopheline control on large lakes by the

use of power-driven boats. King and Bradley (39) and Williams and Cook (59) conducted successful experiments with the distribution of Paris green from airplanes and demonstrated the effectiveness of such application in controlling the production of *Anopheles* mosquitoes.

Gentle, steady breezes seem most satisfactory for dusting and advantage should be taken of the wind to carry the dust across water areas wherever possible. When wind conditions are satisfactory, swaths of 200 to 300 feet in width may be covered during one trip across a lake or pond. A close watch should always be made of the path of the dust cloud. Workmen may frequently need to leave the boat and walk along the shore or wade shallow water in order to take advantage of air movements in distributing Paris green.

Paris green, as used for surface-feeding Anopheline mosquito control, is not very effective against Culicine species which characteristically feed from the bottom of the pool. Fortunately, important Culicine species are rarely found in water areas producing large numbers of *Anopheles quadrimaculatus* in Arkansas. The more common species associated with our important Anopheline mosquitoes are *Culex erraticus*, *Culex apicalis* and *Uranotaenia sapphirina*, species which are of little known importance to man. A slight reduction in the prevalence of these species has been noted on several occasions after Anopheline control was instituted.

Paris green is a poison, and care should be exercised in mixing and applying this larvicide. For mixing the Paris green and lime, the workman should wear a mask to prevent inhalation of the dust. The mask may also be useful at times to the workman when applying the larvicide to the water surface. One employed in handling Paris green dust should be careful not to allow the dust to work under the clothes and come into contact with the body, where it may produce some irritation. It is advisable for the laborer engaged in either mixing or applying the dust to wear an oilcloth or leather apron, preferably with a bib to cover the openings in the front of the clothing.

Care should also be taken that no large lumps of the dust are dropped where persons or livestock might get them. The dust itself, when properly applied, distributes the Paris green so well that there is no danger of poisoning fish or livestock, even when the dust is visible on the vegetation. Paris green as a dust larvicide has been used for years on water areas where cattle drink without any signs of poisoning. King and McNeel (41) report that Paris

green is effective against larvae of salt marsh species, as well as larvae of *Psorophora columbiae* and *Culex quinquefasciatus,* when mixed with water and spread on their breeding places with a sprinkling can. Barber (4) describes the control of *Anopheles gambiae* in Brazil by mixing Paris green with dry sand and gravel, and for some conditions the mixing of kerosene and Paris green with moist sand or gravel for *Anopheles* control.

CONTROL OF ADULT MOSQUITOES

In many communities the mosquito problem is of such vast proportions that control by measures directed against the larvae is not economically feasible at this time. Under such conditions protection against mosquitoes must be employed by using screens, contact sprays, repellents, fumigants, and smudges.

Screens: Mosquito proofing of buildings is a practice which should be emphasized for protecting people against mosquitoes. For mosquito proofing of homes, a durable 16-mesh screen wire cloth should be used on all windows and doors. Windows should be equipped with full length screens. Porches should be screened whenever this can be done at a reasonable cost. Walls and floors should be sealed with substantial materials which will exclude mosquitoes. These features should be included in the designs for all new homes in malarious areas. A screen should be placed in front of the chimney as a further protection against entrance of mosquitoes.

Sprays: Large quantities of insecticidal sprays are consumed each year by residents in important mosquito production areas of Arkansas for the destruction of adult mosquitoes in houses. It is a regular procedure in many homes to close all doors and windows and treat the entire house with an insecticidal spray before retiring for the night. Sington and Watts (52) while working in India found that one part of "Pyrocide 20" in nineteen parts of kerosene oil produced an insecticide equal in mosquitocidal efficacy to the best commercial sprays available on the market in India at about one-half the cost. Home-made sprays should be prepared with water-white kerosene to avoid staining of clothing, walls, and furnishings.

Repellents: Hunters, fishermen, forest workers, road workers, farm workers and others often find it difficult to go about their pursuits without some means of protecting themselves against mosquitoes. Face veils are frequently used but hamper the activities of the individual. Effective repellents applied as lotions are convenient for workmen

and are frequently used in areas where mosquitoes are troublesome.

Howard and Bishopp of the United States Department of Agriculture recommend a repellent which can be prepared by mixing the following materials:

Oil of Citronella	2 ounces
Spirits of Camphor	2 ounces
Oil of Cedar	1 ounce

Hearle (25) suggests the following preparation as a mosquito repellent:

Oil of Tar	2 ounces
Castor Oil	2 ounces
Oil of Pennyroyal	⅛ ounce

Another preparation recommended by Hearle (25) for protection against mosquitoes can be made up of the following materials:

Oil of Pennyroyal	1 ounce
Sweet Oil	6 ounces
Ammonia	1 ounce

Several commercial preparations, claimed by their manufacturers to give satisfactory results in repelling mosquitoes, are available on the market. Granett (22) has conducted some experiments in which he has tested several commercial repellents used against common insect pests, including mosquitoes.

The spraying of porch furniture, walls, and vegetation with an insecticidal spray seems to give temporary relief from mosquito attacks. Workers at the New Jersey Agricultural Experiment Station have found that outdoor gatherings can be protected from mosquitoes by a thorough spraying of the grounds and surroundings with pyrethrum larvicide. The spray is also directed upward so as to saturate the atmosphere with a fine mist of the spray mixture.

Fumigants: Pyrethrum powder made into small pyramids and burned in pans provides a satisfactory means of clearing houses of mosquitoes. The addition of a small amount of alcohol to the top of the heap will help to ignite the powder. The house should be closed as tightly as possible while the pyrethrum is burning. The smoke stupefies the mosquitoes, causing them to drop to the floor. Pyrethrum powder should be burned at the rate of one pound to approximately one thousand cubic feet of house space.

Smudges: Inhabitants of the lowland areas of Eastern Arkansas use damp leaves, old rags, rubber, leather, and

other materials for producing a dense smoke to protect themselves against mosquitoes. These smudges are usually placed in the front yard near the porch and are lighted during the late afternoon. Dry pyrethrum powder can also be used for making smudges.

NATURAL ENEMIES OF MOSQUITOES

Investigations made during the time material was being collected for this paper did not include a detailed study of the various natural factors affecting mosquito production. Incidental observations clearly indicate that such factors as weather conditions, predacious insects, fish, birds and amphibians play important parts in the control of mosquitoes.

Weather Conditions: The weather is frequently an important factor in determining mosquito abundance. In overflow areas of Arkansas, when temperature conditions are suitable, flood waters often provide favorable conditions for the development of hordes of mosquitoes which may persist for several weeks after the recession of the water. Rain at regular intervals during the summer months will keep artificial containers in towns filled with water, providing suitable places for the production of large numbers of *Culex quinquefasciatus* and *Aedes aegypti*. As an instance for illustrating this, during the latter part of July and early August of 1938, light rains fell in Little Rock every few days, keeping roof troughs and other containers filled with water for several weeks. As a result of this condition, together with the formation of temporary pools where *Aedes* and *Psorophora* develop, the city experienced its worst mosquito problem within recent years. On the other hand, the drying of mosquito breeding pools often brings death to large numbers of larvae and pupae.

A dry season sometimes favors a heavy production of *Anopheles quadrimaculatus* in some areas. The malaria rate along the Red River Valley in Little River and Miller Counties in Arkansas was unusually high during the summer and fall of 1938. An investigation of the *A. quadrimaculatus* production in these two counties showed that the river overflowed the valley area, filling the borrow pits and other depressions several times during the late winter and spring months of 1938. There was very little rainfall in these counties during the summer and early fall months and with a high water table, water levels remained rather stable excepting for slight changes brought about by evaporation. The lack of fluctuation of water levels in these permanent water areas was favorable for the production of heavy growths of filamentous algae and certain other

types of aquatic vegetation as well as luxurious marginal vegetation. The dense vegetation provided ideal conditions for a heavy production of *A. quadrimaculatus,* the chief vector of malaria in the Southern States.

Predacious insects: Biological control of mosquitoes is a subject of interest to all mosquito workers and certainly one which needs further investigation. A great deal has been written by various writers, including Hinman (30), concerning the feeding of various animal predators upon mosquito larvae and pupae. Predacious insects will, under certain conditions, play an important part in mosquito control. Many reports of the activities of these predators come solely from aquarium studies, where other foods may be limited, and it is doubtful whether many of these insects have a preference for mosquito larvae and pupae under natural field conditions.

The following groups of insects are among those commonly reported as being predacious upon mosquito larvae: nymphs of *Ephemeridae;* nymphs of *Odonata, Hemiptera (Notonectidae, Corixidae, Nepidae, Belostomidae, Naucoridae, Hydrometridae); Coleoptera* (larvae of *Dytiscidae, Gyrinidae, Hydrophilidae); Diptera* (larvae of *Psorophora ciliata, Psorophora howardii* and *Megarhinus septentrionalis* of the *Culicidae,)* also certain members of the families *Tipulidae, Anthomyiidae, Dolichopodidae.*

Fish: Fish play an important part in mosquito reduction, but adequate control cannot be expected unless conditions are ideal for their propagation and a continuous food supply is present and accessible. Top feeding minnows of the genus *Gambusia* sp. have been used extensively in mosquito control work in many parts of the world, especially in the malarious areas of the Southern United States. Hildebrand (27) has made an extensive study of *Gambusia* in the United States, showing that where conditions are favorable, they may become important factors in Anopheline and Culicine reduction. It has been the observation of the writer that where floatage and surface growth of aquatic vegetation are extensive, providing ideal conditions for the development of larvae of *Anopheles quadrimaculatus,* heavy emergence of this species may take place although the area may be well stocked with top feeding minnows.

Birds: Shore birds have been observed feeding along the edges of temporary pools where mosquito larvae were the dominant forms of animal life; however, no examinations of the stomach contents have been made by the writer. Workers in New Jersey found hundreds of mosquito larvae in the stomach of a killdeer. Nighthawks, swifts, and swal-

lows feed on adult mosquitoes where the mosquito population is heavy. Wild ducks are claimed to be valuable agents in the control of mosquitoes in certain instances.

Amphibians: Matheson (46) has shown that the ordinary spotted salamander, *Diemyctylus viridescens*, is predacious on mosquito larvae. Chandler (9) reports that the western newt, *Nataphalmus torosus*, is an effective enemy of mosquito larvae and that in one particular experiment hundreds of larvae were devoured by this newt during a twenty-four hour period.

LITERATURE CITED

(1) BANG, F. B., QUINBY, G. E., and SIMPSON, T. W. *Anopheles walkeri* Theob. A Wild-caught Specimen Harboring Malarial Plasmodia. Public Health Reports, Vol. 55, pp. 119-120. 1940.

(2) BARBER, M. A., and HAYNE, T. B. Some Observations on the Dispersion of Adult *Anopheles*. U. S. Public Health Reports, Vol. 39, pp. 195-203. 1924.

(3) ———— Food of Culicine Larvae. U. S. Public Health Reports, Vol. 43, pp. 11-17. 1928.

(4) ———— The Present Status of *Anopheles gambiae* in Brazil. American Journal of Tropical Medicine, Vol. 20, No. 2, pp. 249-267. 1940.

(5) BOYD, MARK F. An Introduction to Malariology. Harvard University Press, Cambridge, Mass. 1930.

(6) ———— Bull. Ent. Research XVI (1926) 308.

(7) BRADLEY, G. H. On the Occurrence of *Anopheles walkeri* Theob. in Florida. Southern Medical Journal, Vol. 29, No. 8, pp. 852-875. 1935.

(8) CARTER, H. R., LEPRINCE, J. A., and GRIFFITTS, T. H. D. Impounded Water. U. S. Public Health Bull. 79. 1916.

(9) CHANDLER, A. C. The Western Newt or Waterdog. Oregon Agr. Exp. Station Bulletin 152. 1918.

(10) CLARKE, J. LYDELL. New and Significant Experiences in Mosquito Control in the Des Plaines Valley Mosquito Abatement District. Proc. 24th Ann. Meet. N. J. Mosquito Exterm. Association, pp. 112-128. 1937.

(11) COOGLE, C. P. A Preliminary Report on the Use of Creosote Oil as a Mosquito Repellent. U. S. Public Health Reports, Vol. 38, pp. 437-443. 1923.

(12) DARLING, S. T. Studies in Relation to Malaria.

(13) DEADRICK, W. H. Practical Studies in Relation to Malaria. 1909.

(14) DYAR, H. G. The Mosquitoes of the Americas. Carnegie Institution of Washington, Pub. No. 387. 1928.

(15) FREEBORN, S. B. The Mosquitoes of California. Univ. Calif. Pub. Tech. Bull., Berkley, California. 1926.

(16) FUCHS, A. W. Economic Losses from Malaria. Wire Screen Cloth Mfg. Inst., New York, N. Y.

(17) GEIGER, J. C., PURDY, W. C., and TARBETT, R. E. J. A. M. A. LXXII (1919) 844.

(18) GINSBURG, J. M. Studies of Pyrethrum as a Mosquito Larvicide. Proc. 17th Ann. Meet. N. J. Mosquito Exterm. Assn., pp. 57-72. 1930.

(19) ———————— Mosquito Larvicide. Proc. 21st Ann. Meet. N. J. Mosquito Exterm. Assn., pp. 121-127. 1934.

(20) ———————— Larvicides and a Method of Temporary Protection from Adult Mosquitoes in Limited Areas. Proc. 22nd Ann. Meet. N. J. Mosquito Exterm. Assn., pp. 147-151. 1935.

(21) ———————— Protection of Outdoor Gatherings from the Mosquito Pest. Proc. 23rd Ann. Meet. N. J. Mosquito Exterm. Assn., pp. 166-173. 1936.

(22) GRANETT, PHILIP. The Development of a Practical Repellent. Proc. 27th Ann. Meet. N. J. Mosquito Exterm. Assn., pp. 36-43. 1940.

(23) HEADLEE, T. J. The New Jersey Mosquito Problem. N. J. Agri. Exp. Station Circular 360.

(24) ———————— The Mosquitoes of New Jersey and Their Control. N. J. Agr. Exp. Station Bull. 348. 1921.

(25) HEARLE, ERIC. The Mosquitoes of the Lower Fraser Valley, British Columbia, and Their Control. National Research Council Report No. 17. 1926.

(26) HERMS, W. B., and GRAY, H. E. Mosquito Control. The Commonwealth Fund, New York, N. Y. 1940.

(27) HILDEBRAND, S. R. A Study of the Top Minnow *(Gambusia holbrooki)* in its Relation to Mosquito Control. U. S. Public Health Bulletin 153. 1925.

(28) HINMAN, HAROLD E. Predators of the Culicidae (Mosquitoes). Journal of Tropical Medicine and Hygiene, Vol. 37, No. 9. May, 1934.

(29) ———————— Preliminary Observations on the Hibernation of *Anopheles quadrimaculatus* Say in Southern Louisiana. Southern Med. Journal, Vol. 27, No. 5, pp. 461-465. 1934.

(30) ———————— A Study of the Food of Mosquito Larvae (Culicidae). American Journal of Hygiene, Vol. XII, No. 1, pp. 238-270. July, 1930.

(31) HORSFALL, W. R. Occurrence and Sequence of Mosquitoes in Southeastern Arkansas in 1935. Journal Econ. Ent. 29 (4): pp. 676-679. August, 1936.

(32) ———————— Mosquitoes of Southeastern Arkansas. Journal Econ. Ent. 30 (5): 743. November, 1937.

(33) ———————— Biology of Thibault's Mosquito. 51st Ann. Rep. Ark. Agr. Exp. Station, 1940.

(34) HOWARD, L. O., DYAR, H. G., and KNAB, F. The Mosquitoes of North and Central America and the West Indies. Carnegie Institution of Washington. 4 Vols. 1912-17.

(35) JAKMAUH, PAUL J. The Relation of Mosquitoes to Equine Encephalomyelitis in Massachusetts. Proc. 27th Ann. Meet. N. J. Mosquito Exterm. Assn., pp. 12-18. 1940.

(36) JOHNSON, H. A. Notes on the Occurrence of *Anopheles walkeri.* Southern Medical Journal. 29: 856-857. 1936.

(37) KING, W. V., and BRADLEY, G. H. Notes on *Culex erraticus* and Related Species in the United States. Annals Ent. Soc. Am., Vol. XXX, No. 2, June, 1937.

(38) ———————— The *Anopheles* Density Index in Malaria Research and Control Work. Southern Medical Journal, Vol. XXI, No. 9, pp. 763-767. September, 1928.

(39) ———————— and BRADLEY, G. H. Airplane Dusting in the Control of Malaria Mosquitoes. U. S. D. A. Dept. Circular No. 367. 1926.

(40) ———— Bradley, G. H., and McNeel, T. E. The Mosquitoes of the Southeastern States. U. S. D. A. Misc. Pub. No. 336. 1939.

(41) ———— and McNeel, T. E. Experiments with Paris Green and Calcium Arsenite as Larvicides for Culicine Mosquitoes. Journal Econ. Ent. 31 (1): 85. March, 1938.

(42) Komp, W. H. W. A Guide to the Identification of the Common Mosquitoes of the Southeastern United States. U. S. Public Health Reports, Vol. 38, pp. 1061-1080. 1923.

(43) LePrince, J. A., and Johnson, H. A. Development of a Power Dusting Device for Applying Paris Green as an Anopheline Larvicide. U. S. Public Health Reports, Vol. 44, pp. 1001-1017. 1929.

(44) ———— and Griffitts, T. H. D. Flight of Mosquitoes, Studies on the Distance of Flight of *Anopheles quadrimaculatus*. U. S. Public Health Reports, Vol. 32, pp. 656-659. 1917.

(45) Mail, G. Allen. The Mosquitoes of Montana. Mont. Agr. Exp. Sta. Bull. No. 288. 1934.

(46) Matheson, Robert. The Mosquitoes of North America. Chas. C. Thomas Pub., Springfield, Ill. 1929.

(47) Mayne, Bruce. Infectivity of Anopheles crucians in Nature. U. S. Public Health Reports, Vol. 34, pp. 1355-1357. 1918.

(48) Metz, C. W. Anopheles crucians Wied. as an Agent in Malaria Transmission. U. S. Public Health Reports, Vol. 34, pp. 1357-1360. 1919.

(49) Mitzmain, M. B. Anopheles Infectivity Experiments. U. S. Public Health Reports, Vol. 31, pp. 2325-2335. 1916.

(50) ———— Anopheline Mosquitoes, Their Distribution and Infection Under Field Conditions. U. S. Public Health Reports, Vol. 32, pp. 536-540. 1917.

(51) Schwardt, H. H. Biologies of Arkansas Rice Field Mosquitoes. Arkansas Agr. Exp. Station Bull. No. 337. 1939.

(52) Sington, J. A., and Watts, R. C. The Efficacy of Various Insecticidal Sprays in the Destruction of Adult Mosquitoes. Records of Malaria Survey of India 5, 3. September, 1935.

(53) Smith, L. One Year's Experience with Pyrethrum Larvicide. Proc. 19th Ann. Meet. N. J. Mosquito Exterm. Assn., pp. 128-131. 1932.

(54) Sparks, J. E., Derivaux, R. C., and Taylor, H. A. Malaria Control. U. S. Public Health Reports, Vol. 33, pp. 1154-1158. 1918.

(55) Thibault, James K. Notes on the Mosquitoes of Arkansas. Proc. Ent. Soc., Washington. 12, pp. 13-26. 1910.

(56) Vannote, R. L., and Ginsburg, J. M. Practical Application of Pyrethrum Mosquito Larvicide. Proc. 18th Ann. Meet. N. J. Mosquito Exterm. Assn., pp. 111-120. 1931.

(57) ———— Methods of Applying the Larvicide as a Repellent. Proc. 24th Ann. Meet. N. J. Mosquito Exterm. Assn., pp. 11-15. 1937.

(58) Watson, R. B., and Bishop, E. L. The Control of *Anopheles quadrimaculatus* in the Tennessee Valley. Proc. 27th Ann. Meet. N. J. Mosquito Exterm. Assn., pp. 145-153. 1940.

(59) Williams, L. L., and Cook, S. S. Paris Green Applied by an Airplane in the Control of Anopheline Production. U. S. Public Health Reports, Vol. 42, pp. 459-480. 1927.

(60) Zetek, James. Annals Ent. Soc. America, VI (1913) 5.

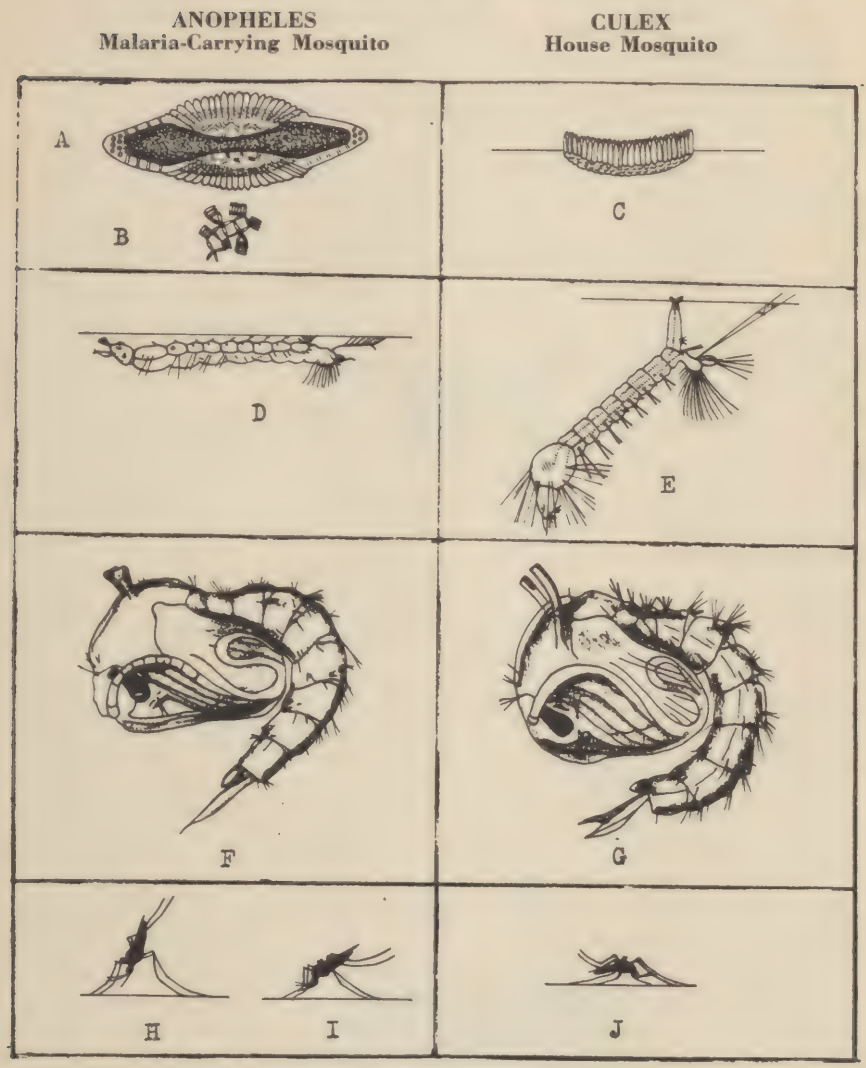
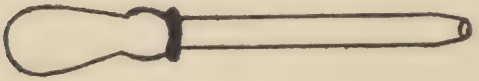


Plate I. MOSQUITO LIFE HISTORIES

Fig. A—Egg of *Anopheles*. Fig. B—Pattern assumed by anopheline eggs on water surface. Fig. C—Egg mass of *Culex* (Common House Mosquito). Fig. D—*Anopheles* larva (note resting position is parallel with water surface). Fig. E—*Culex* larva (note resting position is at an angle with the water surface). Fig. F— Pupa of *Anopheles*. Fig. G—Pupa of *Culex*. Figs. H and I—Resting positions of adult *Anopheles* (note body pointed at an angle toward the resting surface). Fig. J—Resting position of adult *Culex* (note that body is held parallel to the resting surface).

PLATE II.



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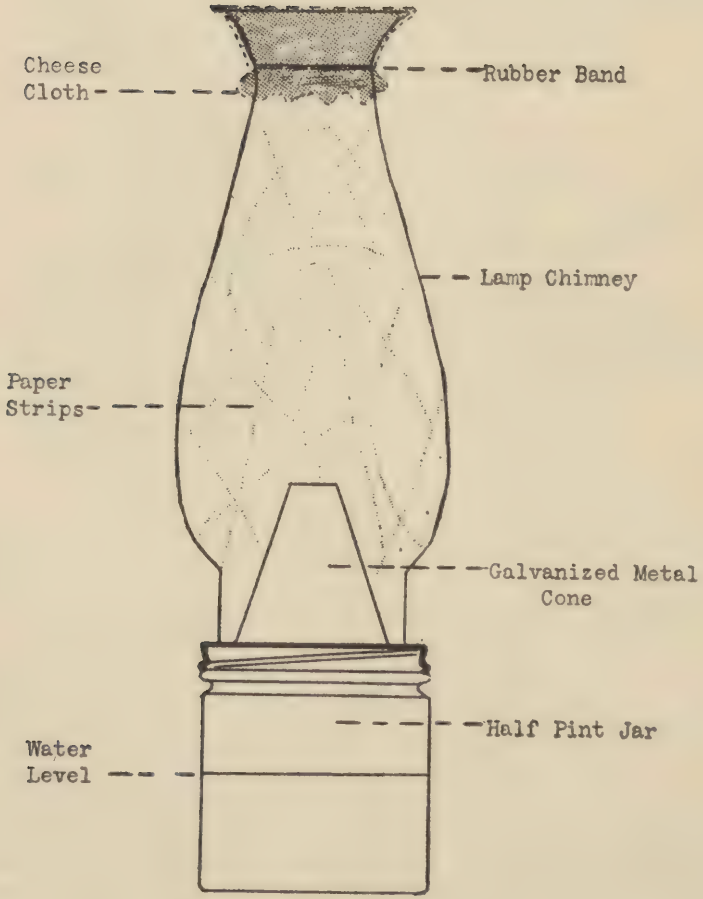
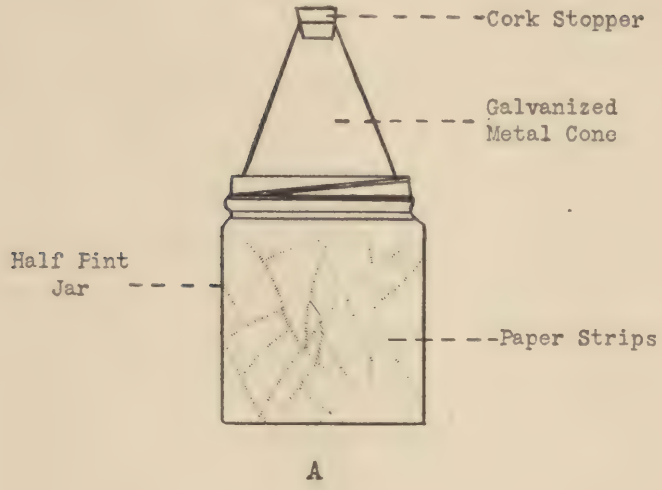


B

A—Dropper for transferring larvae and pupae; B—Cage for mass rearing of mosquito larvae.

PLATE III.



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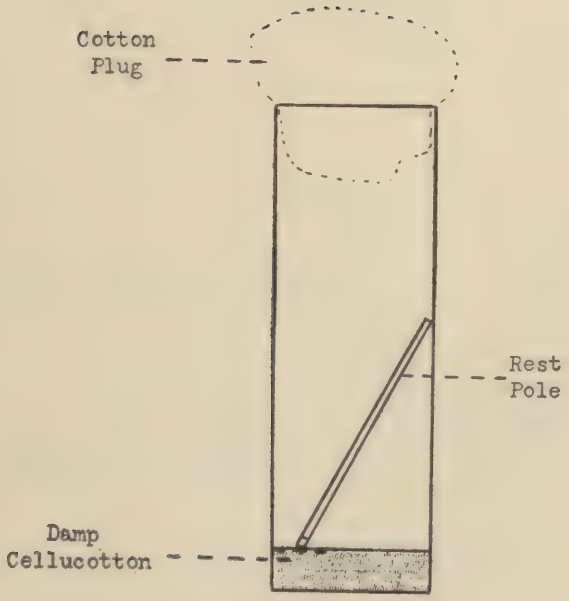
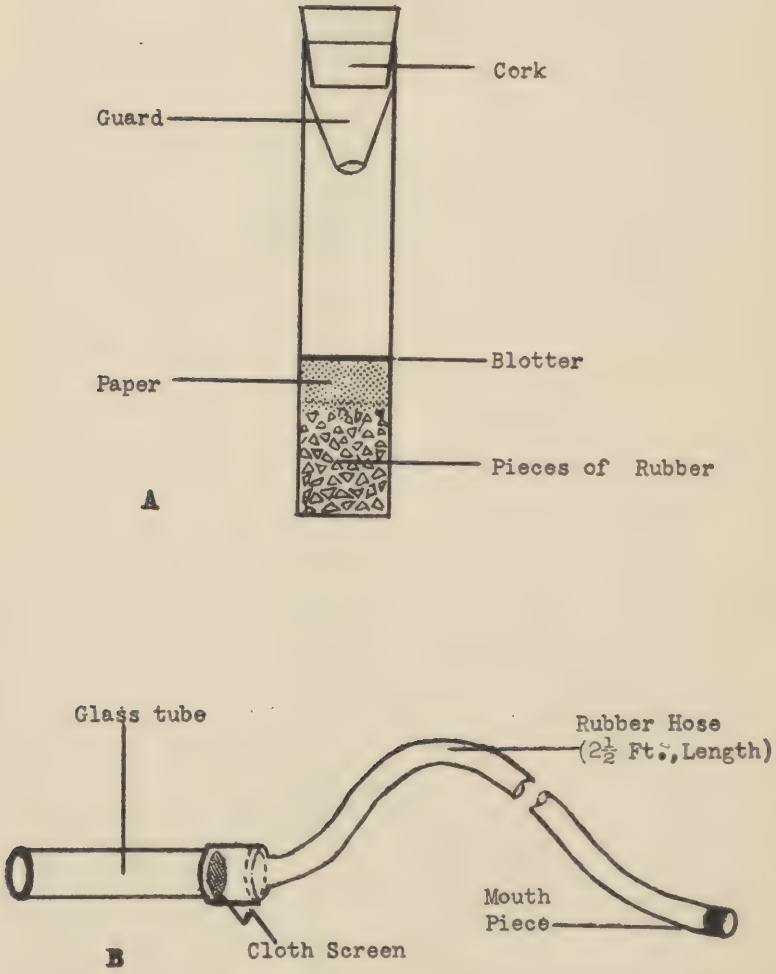


B

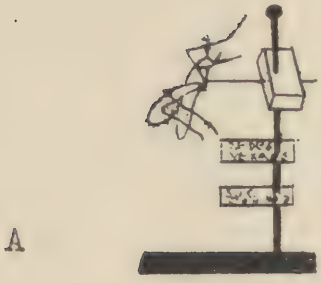
A—Trap for collecting live mosquitoes; B—Mosquito oviposition vial.

PLATE IV.



A—Chloroform killing tube; B—Suction tube for collecting live mosquitoes.

PLATE V.



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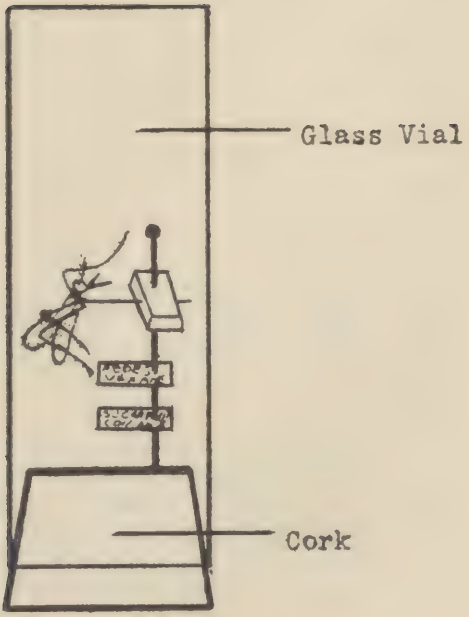
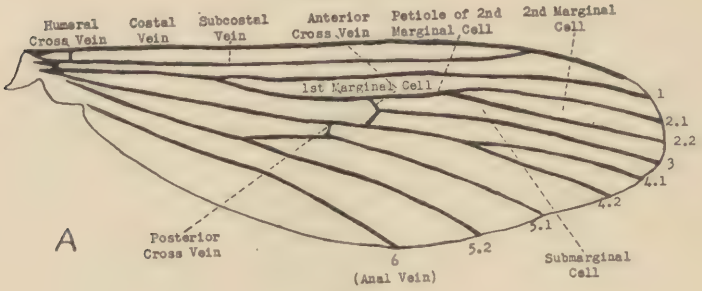
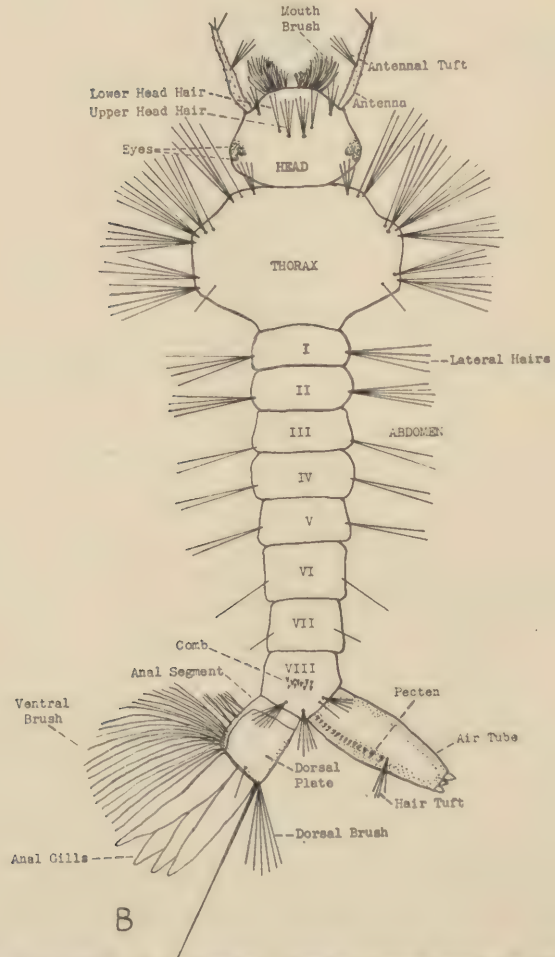


B

A—Mounted adult mosquito; B—Mosquito mounted in display vial (25 by 80 mm.).

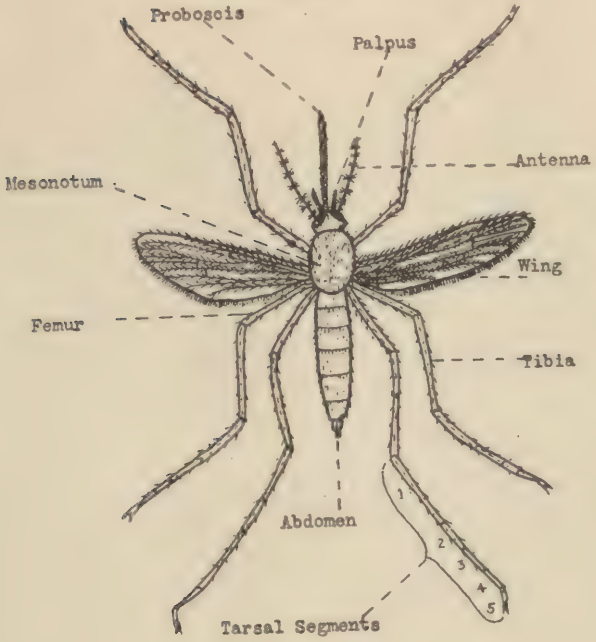
PLATE VI.





***A*—Wing venation of mosquito, showing parts used in the identification of certain species; *B*—Larva of *Aedes* mosquito with parts named.**

PLATE VII.



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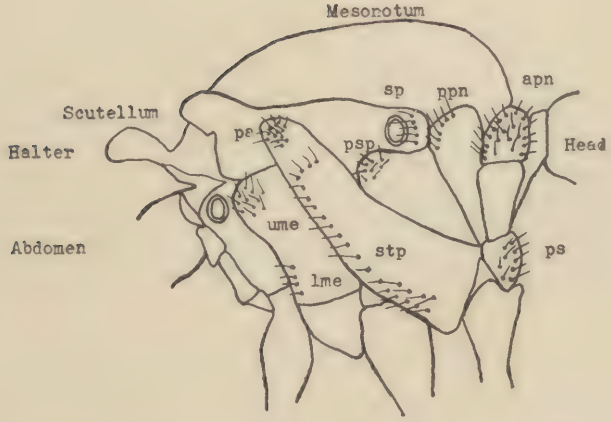
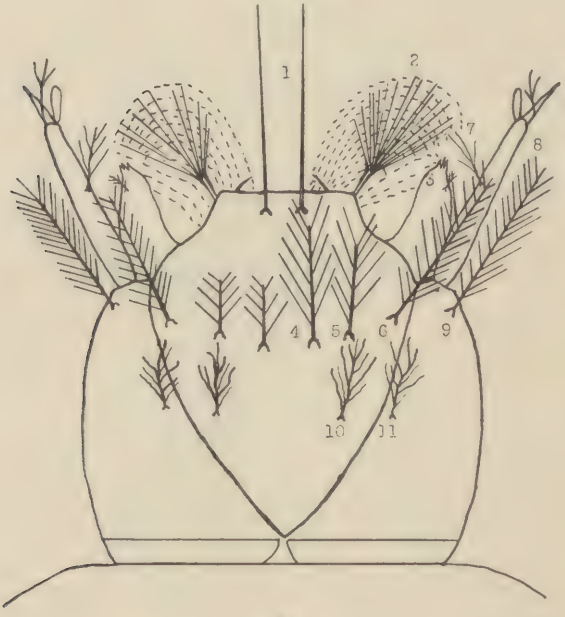


B

A—Diagram of adult mosquito; *B*—Diagram of thorax of a mosquito, showing groups of pleural bristles: *apn*, anterior pronotal; *ps*, prosternal; *ppn*, posterior pronotal; *sp*, spiracular; *psp*, post-spiracular; *pa*, prealar; *stp*, sternopleural; *ume*, upper mesepimeral; *lme*, lower mesepimeral.

PLATE VIII.



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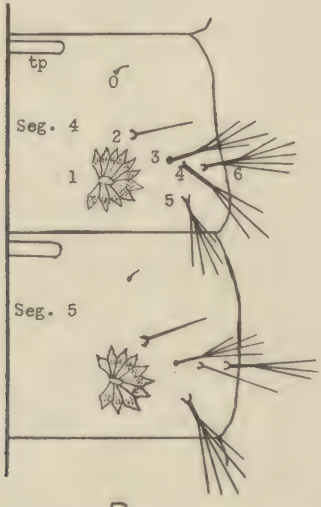


B

A—Dorsal view of head of *Anopheles quadrimaculatus*. Head hairs: 1, inner clypeal; 2, outer clypeal; 3, maxillary palp; 4-6, frontal; 7, antennal; 8, antenna; 9, preantennal; 10-11, occipital.

B—Dorsal view of portion of abdominal segments 4 and 5. Abdominal segment 4: 0, anterior submedian; 1, palmate; 2, antepalmate; 3-5, sublateral, 6, lateral; tp, tergal plate.

PLATE IX.

A—Lake with dense growth of arrowhead (*Sagittaria* sp.) favorable for breeding of *Anopheles quadrimaculatus*; B—salt-marsh area in oil fields where *Aedes sollicitans* and *Aedes taeniorhynchus* breed; C—rock holes in which *Aedes atropalpus* breed; D—ditch in which *Culex quinquefasciatus* breed; E—tree cavity in marsh where *Aedes thibaulti* breed; F—stump hole where *Aedes triseriatus, Megarhinus septentrionalis, Orthopodomyia signifera* and *Anopheles barberi* breed.

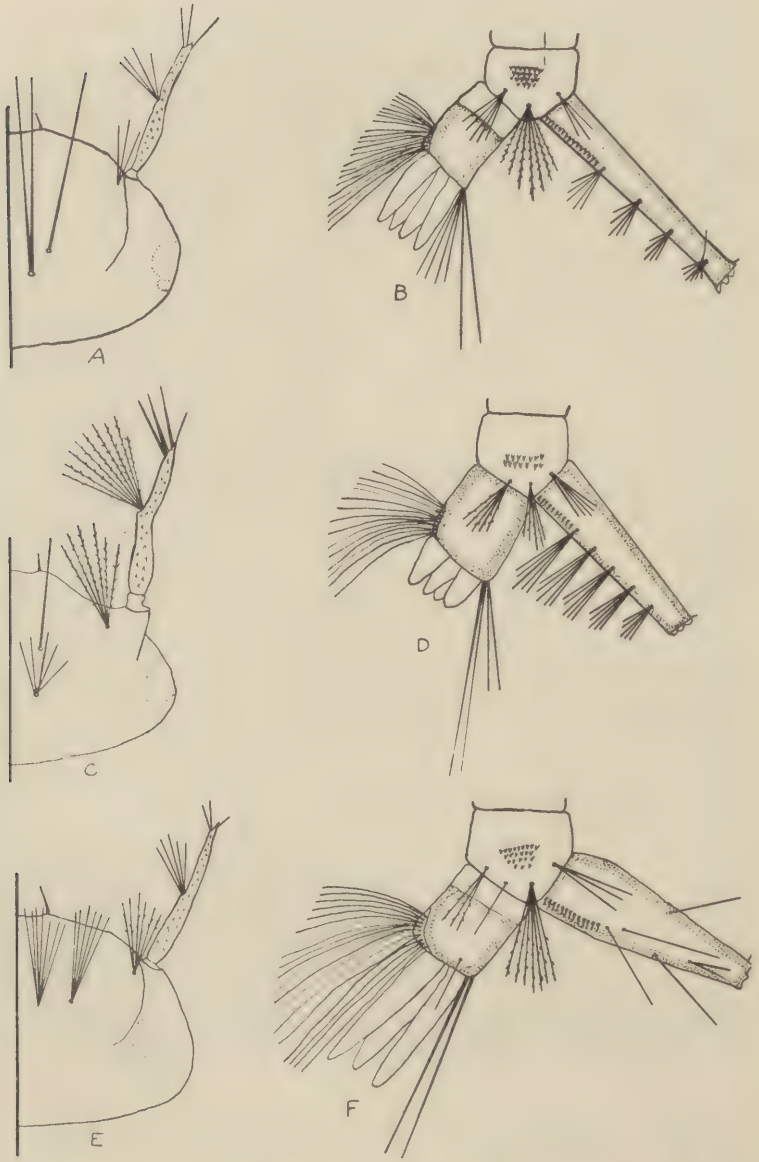
PLATE X.

A—Ditch with suitable conditions for mosquito production; B—same ditch as shown in A, but concrete invert has been installed in the bottom, the sides have been sloped and sodded; C—an inspector checking for mosquito breeding in a marshy area; D—same area as shown in C, but after ditch has been constructed and lined with concrete and stone; E—Permanent ditch construction in which small invert for carrying the water during low flow is within the larger concrete ditch.

PLATE XI.

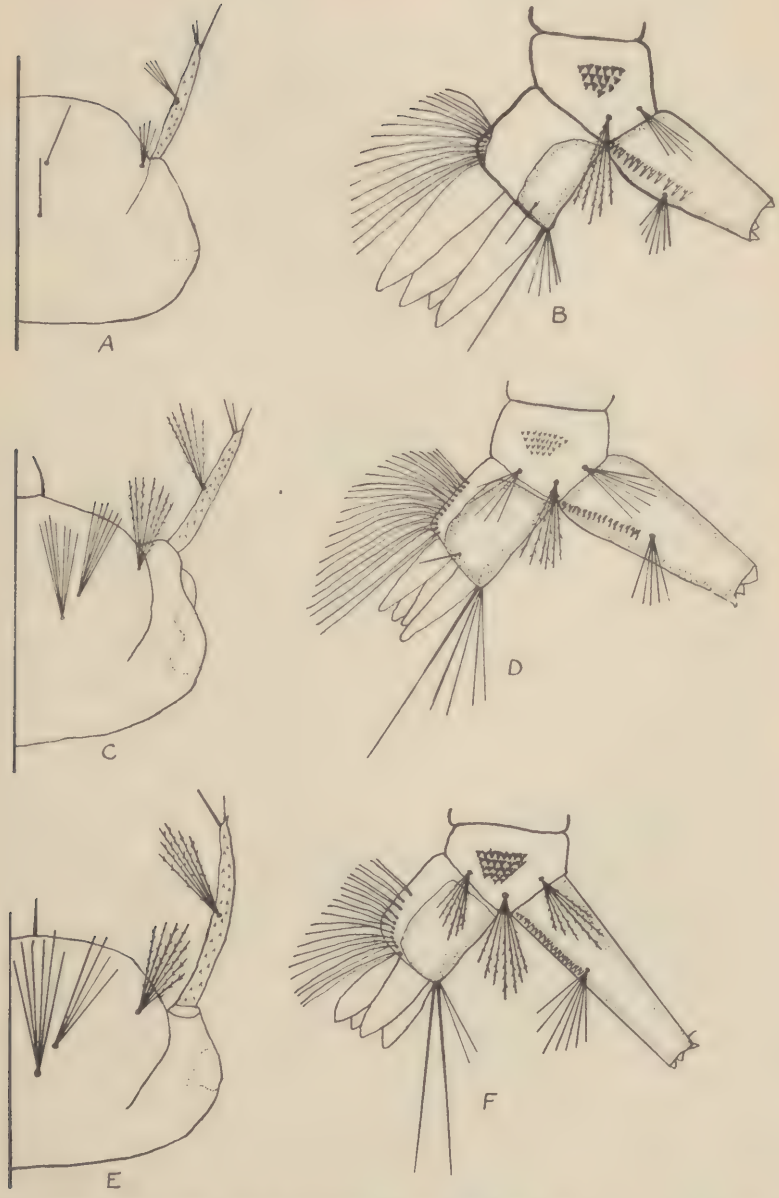
A—Dusting with Paris green for *Anopheles control*; B—spraying petroleum oil for mosquito control; C—New Jersey mosquito light trap with automatic switch.

PLATE XII.



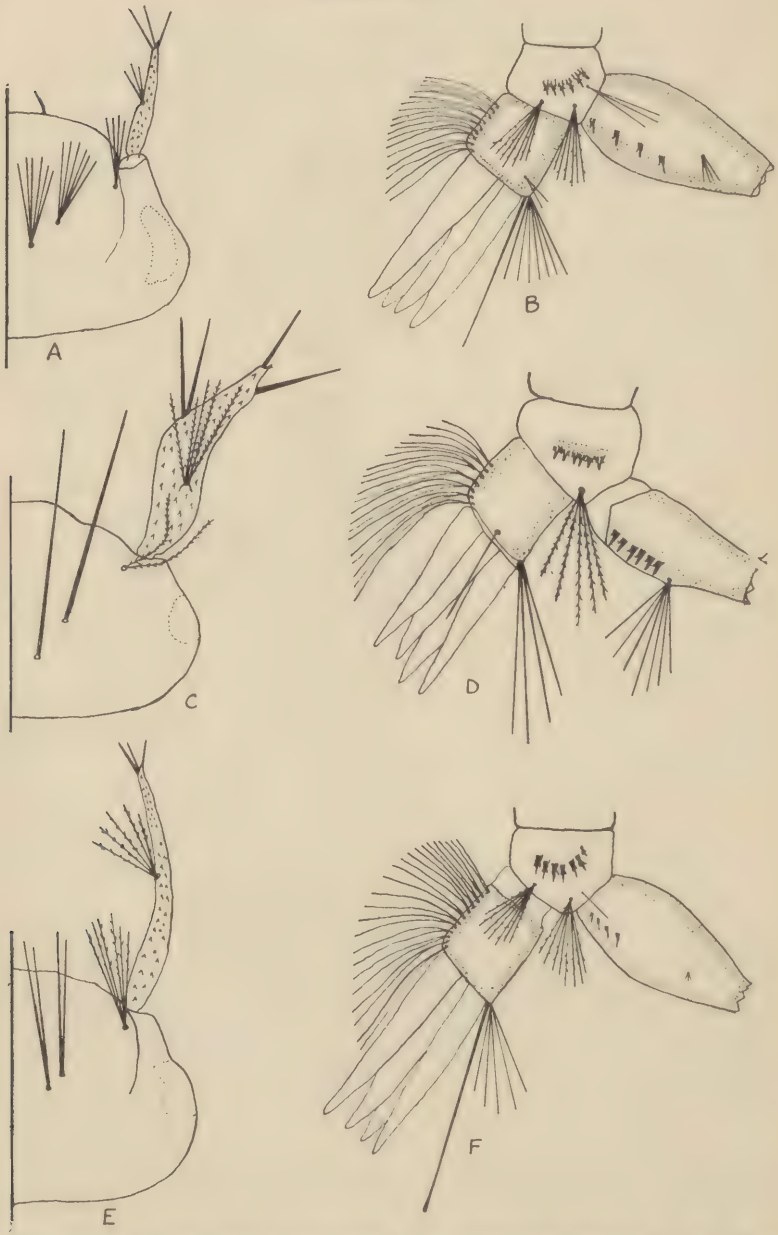
Portions of heads and abdomens of mosquito larvae: A and B—*Culex apicalis*; C and D—*Culex erraticus*; E and F—*Culex restuans*.

PLATE XIII.



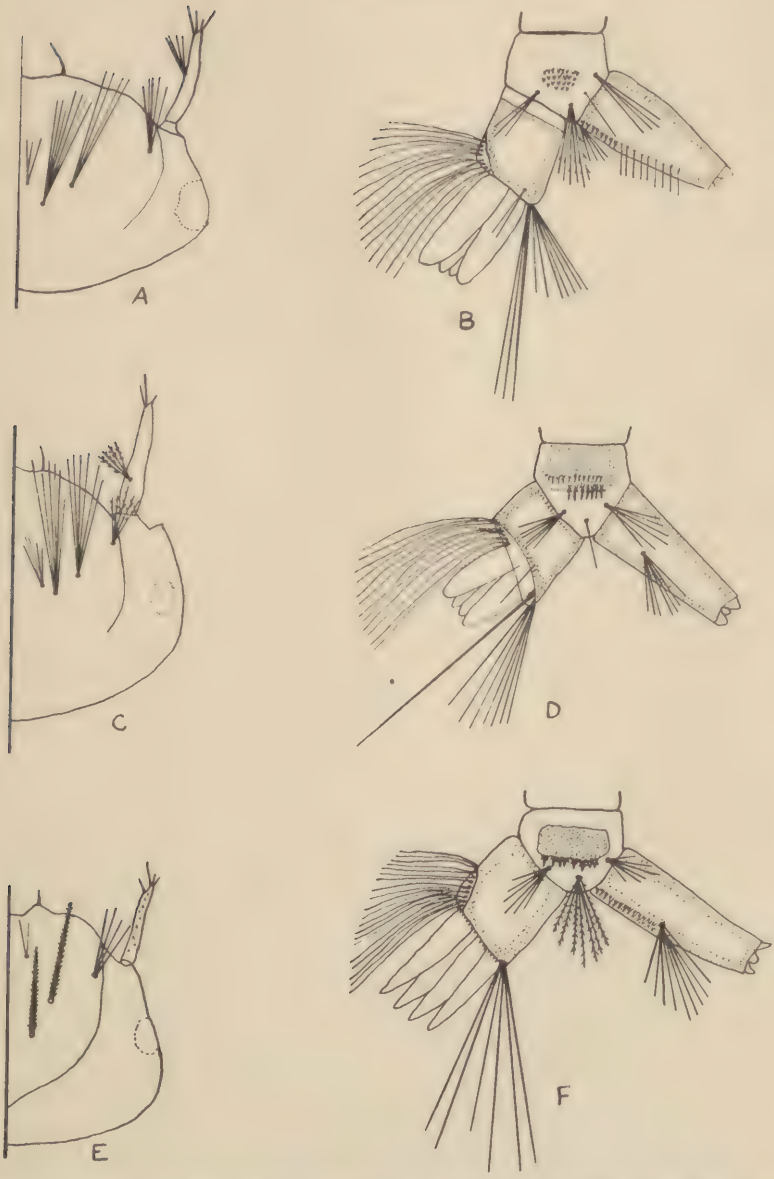
Portions of heads and abdomens of mosquito larvae: A and B—*Aedes atropalpus*; C and D—*Aedes canadensis*; E and F—*Aedes thibaulti*.

PLATE XIV.



Portions of heads and abdomens of mosquito larvae: A and B—*Psorophora columbiae*; C and D—*Psorophora discolor*; E and F—*Psorophora ferox*.

PLATE XV.



Portions of heads and abdomens of mosquito larvae: A and B—*Theobaldia inornata*; C and D—*Orthopodomyia signifera*; E and F—*Uranotaenia sappharina.*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